

BBC

A TIMES OF INDIA PUBLICATION

Volume 5 Issue 4
June 2015 ₹125

Knowledge

SCIENCE • HISTORY • NATURE • FOR THE CURIOUS MIND

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HOW BACTERIA CHANGE YOUR MOOD

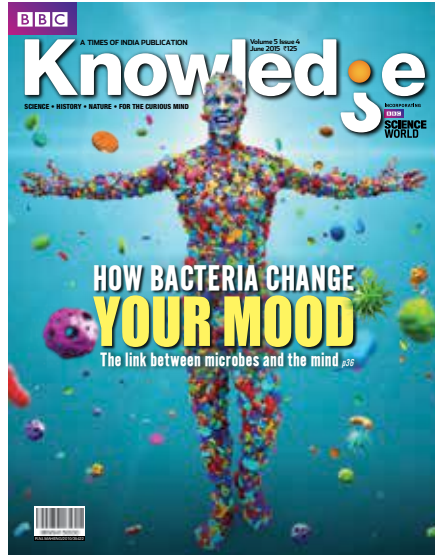
The link between microbes and the mind *p34*



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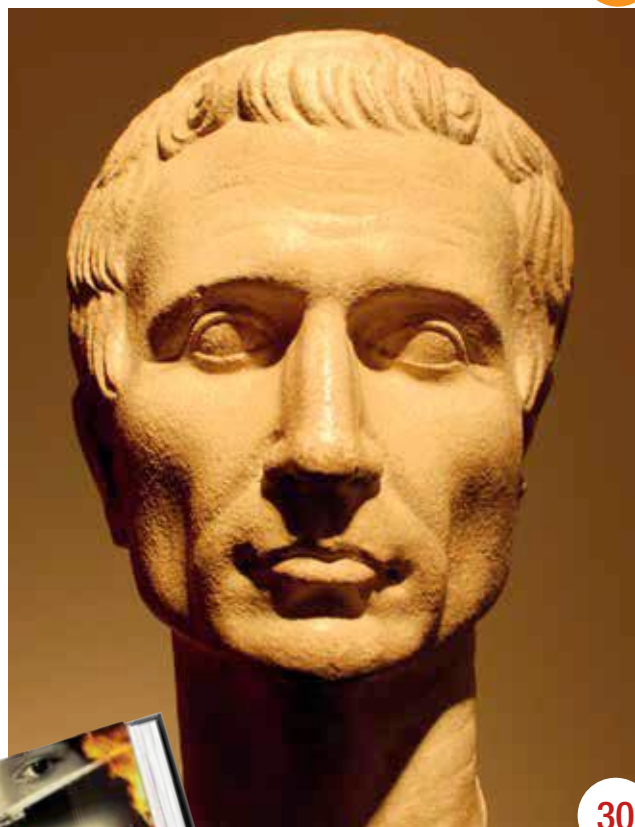
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FROM THE EDITOR



While growing up, I got tired of hearing how a bit of dust and grime is good for my health, and how important it is to build up that fort called immunity. And I remember those sour vegetables, bland yogurts, and other, very awful nameless edible things I had to eat, forced upon me by my folks, which I am trying to force upon my 9-year-old now. You and I and millions after us, will have to endure all of these distastes for a greater purpose – to keep our stomach/gut/intestines balanced and happy.

Which is the focus of this month's cover story. Nicola Davis writes about how new research is suggesting that our gut and the bacteria it decides to play host to dictate not just the distribution of nutrients in the body but also affects our demeanour, stress levels and disposition. And that communication between the brain and the gut can go both ways. Do read on *page 34*.

In other pages, we cover history's two most powerful personalities – Caesar and Hitler – both dictators. Of course we all know who killed Caesar. It was Brutus and Cassius but what we don't know is that the brains behind the deceit were someone else's. Find out the plot and who the bigger villain was on *page 30*. In another must-read essay, the famous biographer Ian Kershaw explores the enduring enigma of Hitler and the devastating but unique impact he had on his people, and the world. On *page 62*.

The rest of the issue has got the good stuff too. Enjoy NASA's new mission, experience the animals of the Namib Desert, and explore newer technologies that seem set to address the issue of climate change.

When you are done reading, we would love to hear your worldview and your feedback. Write in your letters to edit.bbcknowledge@wwm.co.in.

Cheers

Preeti Singh

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EXPERTS THIS ISSUE



Barry Strauss is a military historian who specialises in ancient Greek and Roman history, and has had his work featured in publications like *The Washington Post*, *USA Today* and the *LA Times*. In this issue, he reveals the hidden machinations in Julius Caesar's assassination. *See page 30*



Nicola Davis received an MChem and DPhil in Organic Chemistry from the University of Oxford. She serves as the Commissioning Editor of the *Observer's Tech Monthly*. In this issue, she decodes the impact that microorganisms could be having on our daily lives. *See page 34*



Dr Jennifer Verdolin is an animal behaviour expert, author and also a Visiting Lecturer at Duke University and has contributed to *Scientific American* and *Psychology Today*. In this issue, she draws parallels between the way humans and animals play the mating game. *See page 40*



Sir Ian Kershaw is a historian, author and former professor of the University of Sheffield. He is one of the leading experts in the world on Nazi Germany. In this issue, he examines the mystique that still surrounds the persona of Adolf Hitler. *See page 62*



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Has something you've read in *BBC Knowledge Magazine* intrigued or excited you? Write in and share it with us. We'd love to hear from you and we'll publish a selection of your comments in the forthcoming issues.

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We welcome your letters, while reserving the right to edit them for length and clarity. By sending us your letter you permit us to publish it in the magazine. We regret that we cannot always reply personally to letters.



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www.knowledgemagazine.in



Printed and published by Joji Varghese for and on behalf of Worldwide Media Pvt. Ltd., The Times of India Building, 4th floor, Dr. D. N. Road, Mumbai 400001 and printed at Rajhans Enterprises, No. 134, 4th Main Road, Industrial Town, Rajajinagar, Bangalore 560044, India. Editor- Preeti Singh. The publisher makes every effort to ensure that the magazine's contents are correct. However, we accept no responsibility for any errors or omissions. Unsolicited material, including photographs and transparencies, is submitted entirely at the owner's risk and the publisher accepts no responsibility for its loss or damage. All material published in BBC Knowledge is protected by copyright and unauthorized reproduction in part or full is prohibited. BBC Knowledge is published by Worldwide Media Pvt. Ltd. under licence from Immediate Media Company Bristol Limited. Copyright © Immediate Media Company Bristol Limited. All rights reserved. Reproduction in whole or part prohibited without permission. The BBC logo is a trade mark of the British Broadcasting Corporation and is used under licence. © British Broadcasting Corporation 1996
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Q&A

YOUR QUESTIONS ANSWERED

At what height does a building become a skyscraper? *p8* Could we move polar bears to Antarctica to prevent their extinction? *p9* If you fed cows strawberries, would it give their milk a strawberry flavour? *p11* Why are MRI scanners so noisy? *p13*

EXPERT PANEL

Susan Blackmore (SB)

A visiting professor at the University of Plymouth, UK, Susan is an expert on psychology and evolution.

Alastair Gunn

Alastair is a radio astronomer at Jodrell Bank Centre for Astrophysics at the University of Manchester, UK.

Robert Matthews

Robert is a writer and researcher. He is a Visiting Reader in Science at Aston University, UK.

Gareth Mitchell

As well as lecturing at Imperial College London, Gareth is a presenter of *Click* on the BBC World Service.

Luis Villazon

Luis has a BSc in computing and an MSc in zoology from Oxford. His works include *How Cows Reach The Ground*.

ASK THE EXPERTS?

Email our panel at bbcknowledge@wmm.co.in
We're sorry, but we cannot reply to questions individually.

VITAL STATS

8.8cm

Is the length of the longest nose on a living human. The measurement was taken from the bridge to the tip

How can you 3D print a person?

Pictured Here is Andreas Kroker, a customer of German 3D-selfie firm TWINKIND. To produce such a 'mini me', the subject stands in a large 3D scanner. An assembly of high-resolution cameras instantly captures over a hundred images of the person from multiple angles. On the computer, the subject can be viewed in 3D, rather like in the movie *The Matrix* where Keanu Reeves appears suspended in time. Then comes a process a bit like Photoshopping, but in multiple dimensions. A technician tweaks the digital 3D model to remove any

blemishes or errors from the scanning process and to touch up the image. Then, a specialist industrial grade 3D printer builds up the figure by spreading coloured powder in layers. As it goes along, a precise inkjet applies a binding polymer to hold it all together. The printer combines uncanny accuracy with pretty impressive scale, offering prints up to 35cm tall. GM

TWINKIND's 3D printers create perfect replicas of individuals – Andreas Kroker's 'mini me' is on the left





Why do we laugh when tickled?

Tickling affects the same unmyelinated nerve fibres that carry pain signals, and our most ticklish parts are vulnerable spots, such as our neck, abdomen and armpits. Laughing for joy, amusement and tickling all activate brain areas controlling facial and vocal reactions, but only tickling activates the hypothalamus, which is an area that anticipates pain. It's possible that tickling is interpreted as a threat and the laughter is a social signal of submission to prevent us from getting hurt or to defuse a scary situation. SB

How do stem cells turn into specific types of cells?

Stem cells are the ultimate substitutes in the processes of life, able to step in and play the part of specialist cells at a moment's notice. Embryos are full of all-purpose 'pluripotent' stem cells, but we all maintain a population of adult stem cells, whose more limited repertoire is used for repairing damage. Exactly how stem cells do all this is still being worked out. What is known is that they congregate in so-called niches, exposed to proteins that communicate the

condition of tissue around them. At key stages in the development of the embryo, or following disease or injury in adult organisms, these proteins activate the stem cells, switching on the appropriate genes for the specific role they're required to play. Once their mission has been completed – for example, by providing fresh skin cells to repair a wound – the stem cell niche goes back to its monitoring role, awaiting the next call to action. RM



Embryonic stem cells can play the part of any cell at a moment's notice

What makes us trust some faces over others?

Simple facial features will contribute to how much we trust someone. Experiments show that faces with higher inner eyebrows, pronounced cheekbones and a wide chin are judged as more trustworthy. The amygdala, a structure associated with fear and other strong emotions, can respond to a face within 33 milliseconds (three-hundredths of a second).

Volunteers were shown both real and computer-generated faces for such short periods that they did not consciously

see them. Nonetheless, they could still make judgments of trustworthiness. This high-speed assessment makes sense in evolutionary terms since detecting threats or judging strangers as dangerous could be crucial to survival. So we should not be surprised if we get a feeling about someone before we've even recognised them. Even so, we should be wary. There is little evidence that people with high cheekbones and eyebrows really are any more honest. SB

We wouldn't trust a bloke with half a beard, no matter how high his cheekbones were



At what height does a building become a skyscraper?

There is no specific height at which a tall building is classified as a skyscraper. For most engineers, the definition is a tower block of 'considerable height' that has multiple storeys. Structurally, the walls should not be load-bearing but instead hung on a framework of steel girders and usually a central spine. GM



How is the sex of some species determined by temperature?

Temperature-dependent sex determination is seen in most turtles and all crocodiles and alligators. The mechanism isn't well understood, but one piece of the puzzle is the enzyme aromatase, which converts the male hormone testosterone into the female hormone oestrogen. This enzyme reacts very slowly at 25°C but much more quickly at 30°C, so females hatch out of eggs that are incubated at warmer temperatures. Which seems simple, except that in some species the females hatch out of the cooler eggs, and in others, males only hatch from eggs in a middle range of temperatures. LV

The sex of many turtle species is determined by the temperature at which the eggs are incubated



Could we move polar bears to Antarctica to prevent their extinction?

This just swaps one disaster for another. In Antarctica, orcas and leopard seals hunt in the water. None of the other seals and penguins that live there have evolved any defensive behaviours while they are on the ice. If polar bears were suddenly introduced, there would be a brief population boom, followed by a crash, as the local seals and penguins were hunted to extinction. Even though the sea ice in Antarctica is currently growing, climate change is likely to affect the region in ways that will probably be just as bad for polar bears as the shrinking sea ice in the Arctic. LV



"Oh. I've eaten all the seals. Better p-p-pick up a penguin"



Has the population boom affected our evolution rate?

Is the rate of human evolution increasing with population growth?

Larger populations create more chances for genetic mutations to occur, and this means more variations for natural selection to either favour or weed out. But in big populations, it takes longer for changes to spread. The fastest rate of evolution occurs when a population is split into isolated subgroups that can't interbreed due to geographic or cultural barriers. Travel and communication have broken

down many barriers, so our genes get blended together instead of splitting into subspecies. A 2007 study found that we are evolving about 100 times faster than at any other period in our history. But 'modern' for an evolutionary biologist means the last 5,000 years. It's too soon to tell how our evolution has been affected by the population explosion of the last few centuries. LV

Does nasal hair have any useful function?

Certainly! It's a filter for dust, pollen, spores, viruses and bacteria. Particles stick to the wet surface of your nose hairs, which prevents them from reaching your lungs and causing infection. Eventually you'll either blow the nasties into a tissue, or swallow them, to be destroyed in your stomach. LV



VITAL STATS

1,013

confirmed exoplanets have been discovered by NASA's Kepler Space Telescope, as of January 2015

Could life have originated deep inside Earth?

The idea that life could thrive deep below Earth's surface was once regarded as heretical. Lacking any obvious source of energy, such as sunlight, and subjected to intense heat and pressure, subterranean organisms would seem to have little chance of survival. Yet since the 1980s, bacteria, fungi and worm-like creatures have been found lurking kilometres down in mine boreholes and deep sea sediments.

These organisms have extraordinary sources of energy. For example, some bacteria rely on the reactions between water and

rocks to get their energy.

Dating techniques suggest bacteria have existed at depths of several kilometres for at least 30 million years. What isn't clear is where they fit in to the history of life on Earth: were they washed down, or are they progenitors of life on the surface? Either way, their existence has boosted hopes for life on Mars. While none has been found on the surface, NASA's Curiosity rover recently detected methane coming from within the planet – which may be the result of subterranean organisms. RM

Tube worms live at hydrothermal vents and use bacteria to obtain nutrients from the water

VITAL STATS

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Species of British pollinating bees and wasps have become extinct since 1850. The decline is due to changing agricultural practices

TOP TEN CIVILIAN AIRCRAFT

(By maximum take-off weight, MTOW)

1. Antonov An-225

MTOW: 640 tonnes
First flight: 21 December 1988
Country of origin: Soviet Union/Ukraine

2. Airbus A380-800

MTOW: 590 tonnes
First flight: 27 April 2005
Country of origin: Multinational

3. Boeing 747-8

MTOW: 442 tonnes
First flight: 8 February 2010
Country of origin: USA

4. Antonov An-124

MTOW: 405 tonnes
First flight: 26 December 1982
Country of origin: Soviet Union

5. Boeing 747-400

MTOW: 397 tonnes
First flight: 29 April 1988
Country of origin: USA

6. Airbus A340-600

MTOW: 380 tonnes
First flight: 23 April 2001
Country of origin: Multinational

7. Boeing 777-300

MTOW: 299 tonnes
First flight: 16 October 1997
Country of origin: USA

8. McDonnell Douglas MD-11

MTOW: 273 tonnes
First flight: 10 January 1990
Country of origin: USA

9. Airbus A350

MTOW: 272 tonnes
First flight: 14 June 2013
Country of origin: Multinational

10. Ilyushin Il-96

MTOW: 270 tonnes
First flight: 28 September 1988
Country of origin: Soviet Union



If you fed cows strawberries, would it give their milk a strawberry flavour?

Diet definitely affects the flavour of the milk of all mammals. A 2008 study at Copenhagen University gave flavour capsules to nursing mothers and found that the taste made its way into their breastmilk within minutes. And dairy farmers have long known that weeds in the pasture can taint the taste of cow's milk. French Gruyère de Comté cheese even tastes different when it is made from the milk of cows fed on mountain grass, rather than in the valley pastures. Feeding strawberries to cows might seem extravagant, but fruit farmers often have a lot of leftover produce that isn't good enough to sell. A 2007 study looked at the practicalities of feeding leftover pears and peaches to dairy cattle, but

it made no mention of any effect on the taste of the milk. This may be because fruit flavours don't hang around for long – the Copenhagen breastmilk study found that non-citrus fruit flavours only affected the milk for a few hours.

The Dairy Research Laboratory of Australia experimented in 1989 with an oat and sunflower seed supplement in cattle feed, as a way of increasing their milk's fat content. Researchers found that the oats stimulated the bacteria in one of the cows' stomach compartments to turn the sunflower oil into a chemical called gamma-dodec-cis-6-enolactone. This gave a noticeable raspberry flavour to the milk, and even the beef! LV

Why don't vultures get food poisoning from eating rotten meat?

The acid in a vulture's stomach is almost 10 times as concentrated as ours. This destroys bacteria so efficiently that vulture droppings are actually more hygienic than the meat they eat! But a strong stomach isn't enough by itself, because once bacteria have multiplied in a decaying carcass, they release chemical toxins that aren't destroyed by acid. To counter this, vultures absorb the toxins directly through the lining of their throat and then neutralise them using antibodies present in their blood. LV



Yum.
Delicious
rotten
carcass
for tea!

Why hasn't evolution sorted out eye defects?

Vision defects such as myopia (short-sightedness) aren't caused by just one single gene. There's some evidence that short-sighted people have a higher than average IQ, which may be because the same genes affect the eyes and brain. Vision defects often have environmental causes as well. Myopia is more common in people who do a lot of close-up work, have saturated fat in their diet and sleep with a light on. These are all relatively new in our evolutionary history. LV

Superman's disguise would be rubbish if no-one wore glasses



Could a train break the sound barrier?

A conventional train never could, because the friction of metal on metal would melt the wheels and the track. But in November 2014, Japan's experimental Shinkansen maglev ('magnetic levitation') train managed 500km/h (311mph), which is about Mach 0.4. Levitating the train over the tracks reduces friction. The entrepreneur Elon Musk has proposed the 'Hyperloop' concept, in which a train zips along at near supersonic speed through a partially evacuated tunnel. But there are no serious plans for a train that crosses the sound barrier, because coping with the pressure wave at the front of the vehicle remains an insurmountable problem for currently available technology. GM



Would the wrong type of snow still be an issue with Japan's maglev train?

Horseshoe Falls, Niagara: tall, but not 183m tall

Why does looking down from the top of an object seem further than looking up from the bottom?

Distance estimation itself is complicated: it can involve binocular vision, overlaps and shadows, changes in colour with distance and many other cues. Also, vertical distances and sizes are generally overestimated compared with horizontal ones. This is especially the case for larger objects, and particularly when looking down from the top. When the explorer Louis

Hennepin first saw the 51m (167ft) Niagara Falls in 1677, he estimated them to be 183m (600ft). He said that they "are so prodigious high, that it would make one tremble". His fear may have actually led to this gross overestimate: experiments show that people who are afraid of heights overestimate more when looking down than those who are not. SB

Do plants have a form of consciousness?

Plants don't have nerve cells, let alone a brain. Some plants can signal to each other, and to insects, using chemical messenger compounds, but that's quite different from consciousness. Plant 'thoughts' would be at the level of an unconscious reflex at most. Human concepts such as emotion and self-awareness simply don't apply when talking about plants. LV

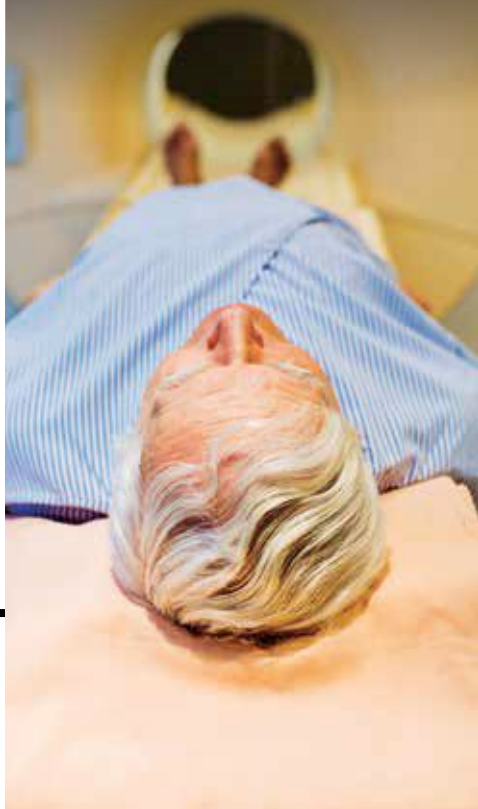
Criticise his leaves all you want – you won't upset him!



Why are MRI scanners so noisy?

MRI scanners **PRODUCE** very powerful, rapidly fluctuating magnetic fields, and work by measuring the radio waves that are given off by the hydrogen atoms in your tissues as a result. The magnetic fields are generated by passing electrical pulses through large, heavy coils of wire. The wire expands and contracts very slightly as the magnetic field rises and falls and this makes the coil vibrate. MRI scanners use fields 60,000 times greater than the Earth's magnetic field, so these vibrations can be quite strong. The noise is the coils banging against each other, and it can be as loud as a balloon popping next to your ear. LV

MRI scanners are far too noisy to offer the chance of a cheeky nap



Eagles handle turbulence better than planes

Do birds suffer from turbulence when flying?

Birds normally fly close to the ground, around trees and buildings, or soar in the rising air of thermals. Both are high-turbulence environments, but birds have two adaptations that make them much better at coping with it than planes. Nerves at the base of their feathers allow them to detect the flow of air over their wings and monitor turbulence very accurately. Instead

of waiting for an air gust to buffet the entire wing, they can anticipate each minor eddy and continuously make tiny adjustments. Large soaring birds, like eagles and vultures, can also quickly tuck their wings downward and coast through a small patch of turbulence. Each tuck lasts just a third of a second but it greatly reduces the sudden loading on their wings. LV

How can phones get thinner and lighter yet improve their features?

To get better features, you need greater processing power, and to get that you must squeeze more transistors into the phone's chips. A handset today crams in twice as many transistors as one from two or three years ago. It's a feat of miniaturisation where each component is smaller and lighter, allowing you to squeeze more processing out of a slice of silicon. Battery improvements are not quite as dramatic, but lithium-ion devices store ever more charge per kilogram, doubling performance since the 1990s. GM



HOW IT WORKS VOLVO CYCLIST DETECTION

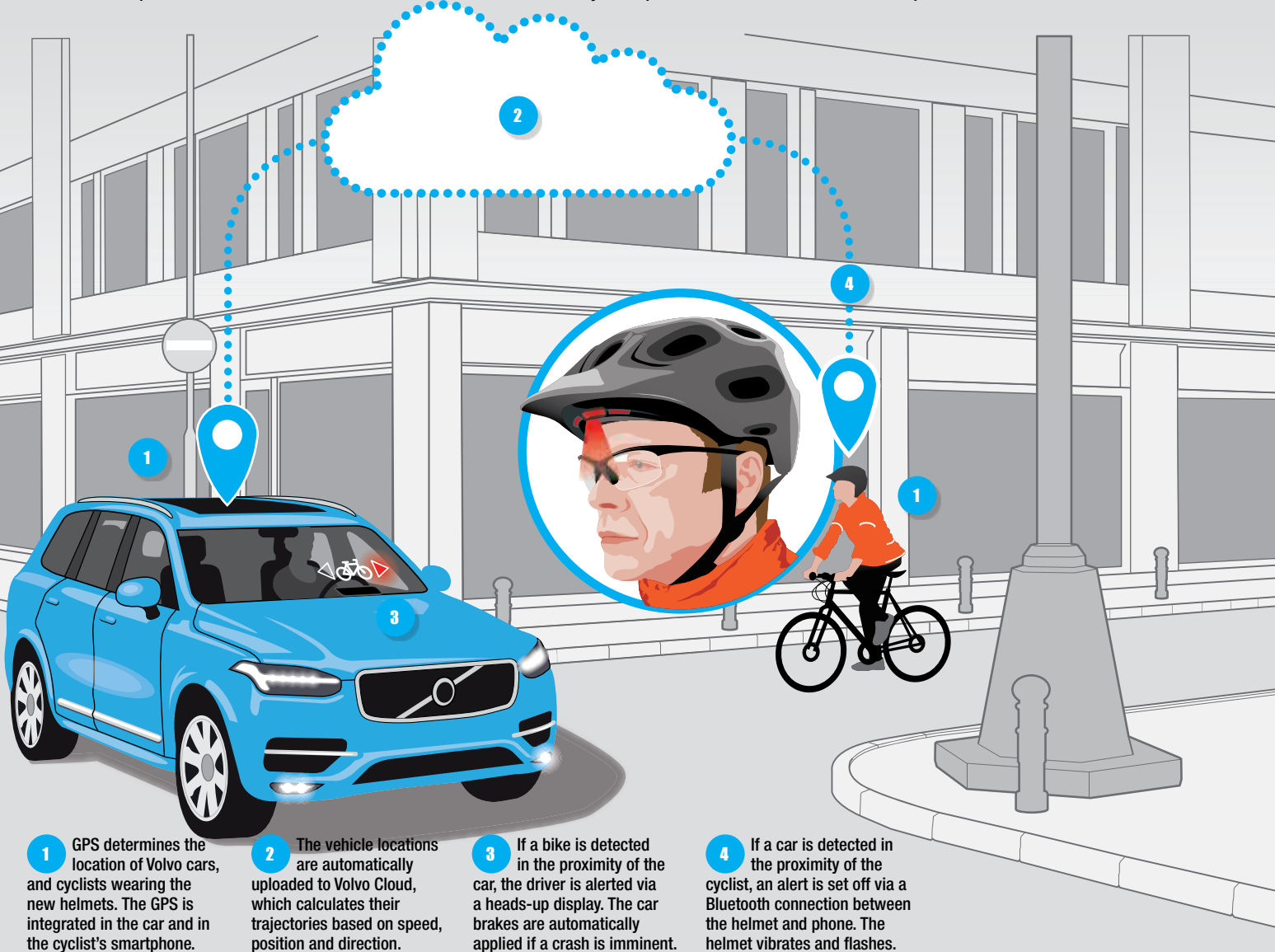
A prototype helmet that warns both cyclists and drivers of potential collisions has been unveiled by Volvo Cars.

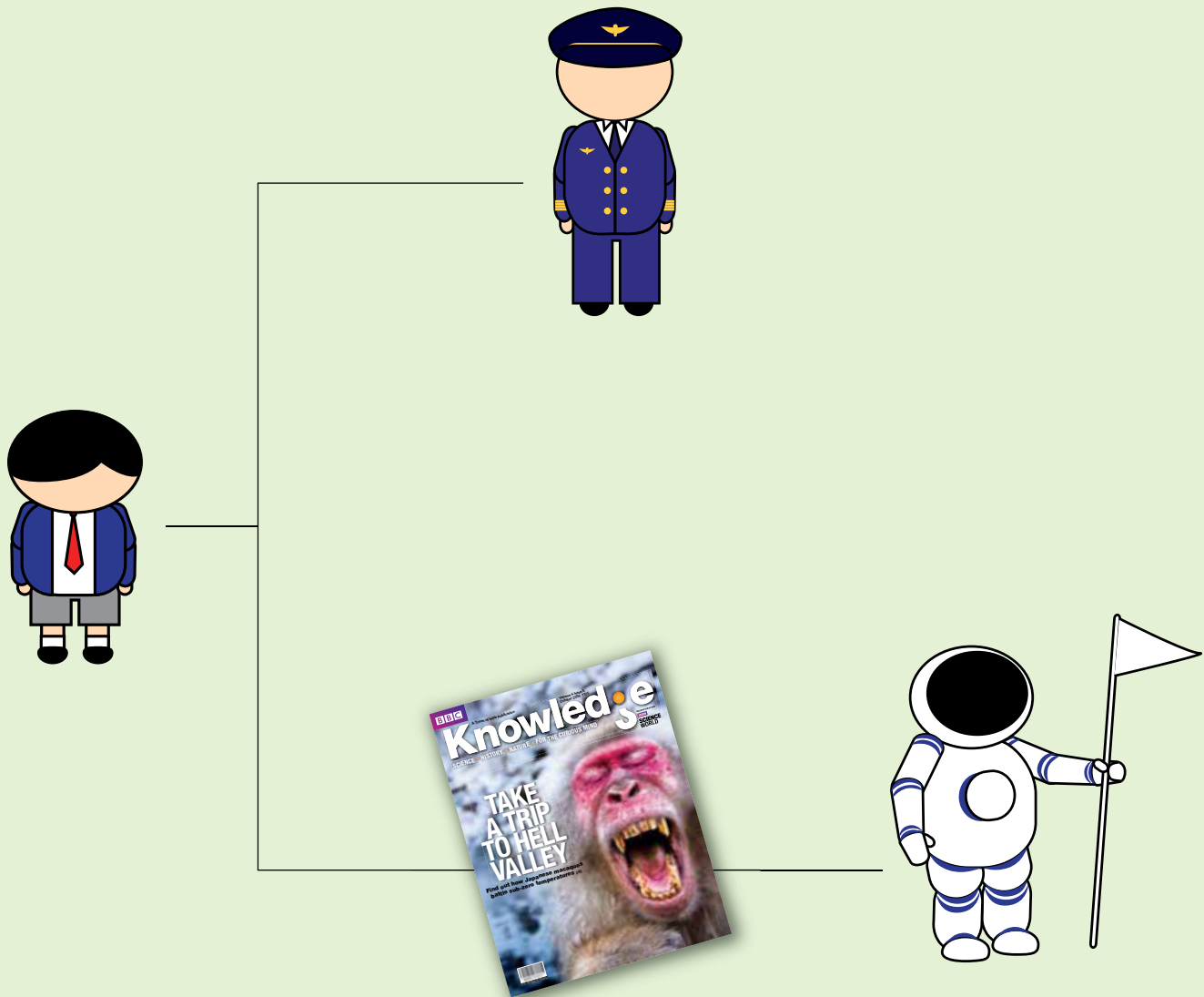
The helmet connects to a cyclist's smartphone using Bluetooth. Used in conjunction with common cycling apps such as Strava, the cyclist's position, speed and direction are tracked via GPS. This information is uploaded to the Volvo Cloud and the

cyclist's likely trajectory is calculated. This data is sent to nearby Volvo cars possessing "City Safety" technology. If a car detects a bike nearby, there's an audible warning and a visual alert on a heads-up display. The car can even brake automatically if a collision is imminent, thanks to its built-in radar.

The car's position is also uploaded to the Volvo Cloud and sent to the cyclist's phone. If a collision

looks likely, the phone signals the helmet, which vibrates and flashes its built-in lights to alert the cyclist. GPS can't place a car to pinpoint precision – 95 per cent of the time, it's only accurate to within 3m. But Volvo doesn't see this as a drawback. "An increased awareness of potential dangers can help reduce possible crashes," claims Volvo's vice president Klas Bendrik.





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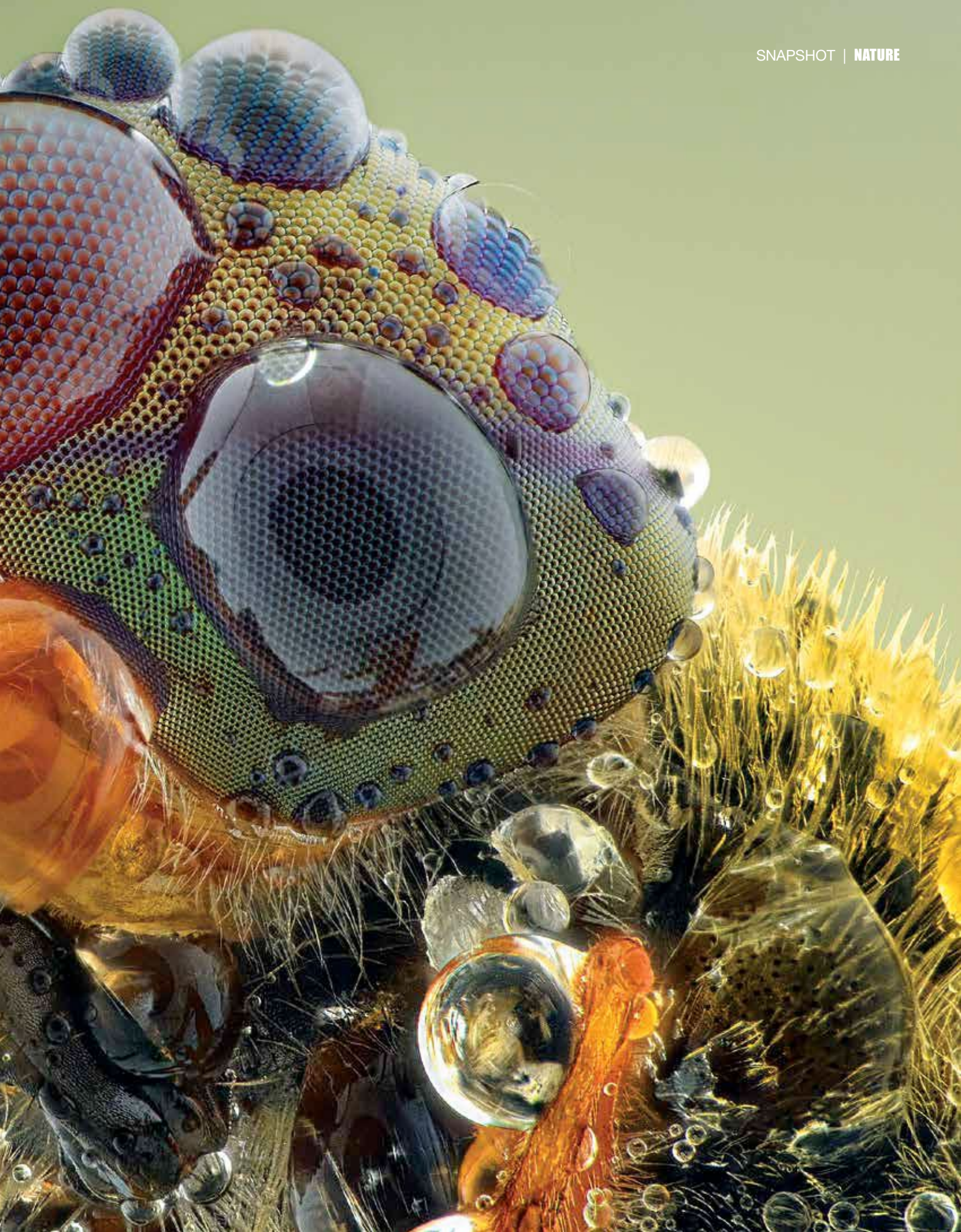


Eye drops

Although it looks like the concept art for an alien villain in a sci-fi movie, this is actually a photo of a black soldier fly. The fly only measures 15-20mm, but this image was taken through a macro lens, giving it a larger than life appearance.

On the surface of the critter's compound eye are tiny blobs of water. But why do the droplets sit there? "There is a high energy cost for a liquid to sit on a surface. A water molecule would much rather be surrounded by other water molecules, where it has a lower energy," explains Imperial College's Dr Patricia Hunt. And why are the droplets spherical? "Water has a high surface tension. It costs energy to make the surface area larger. Hence, rounded droplets with a small surface area have a lower overall energy than other shapes."

YUDY SAUW





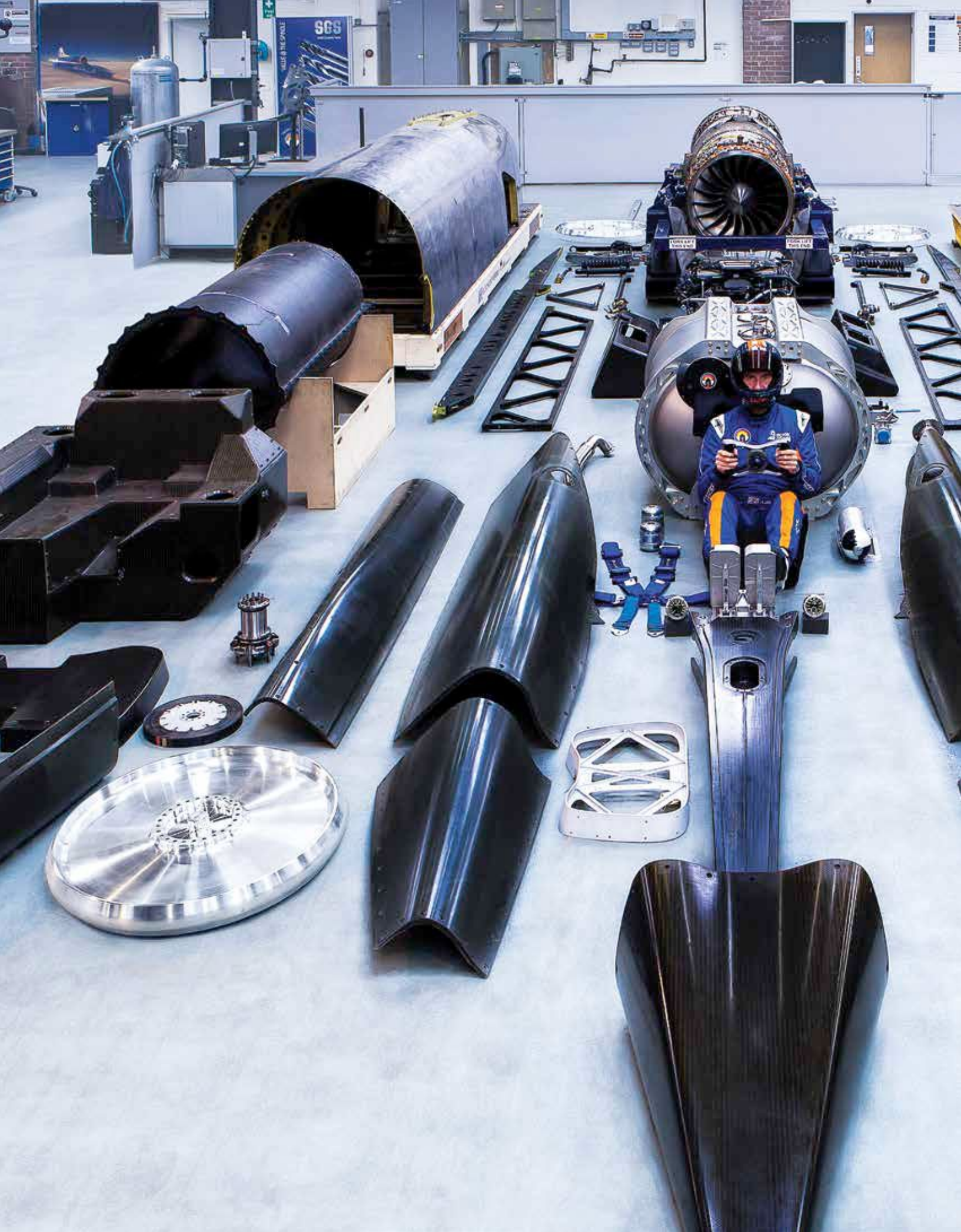
Flying high

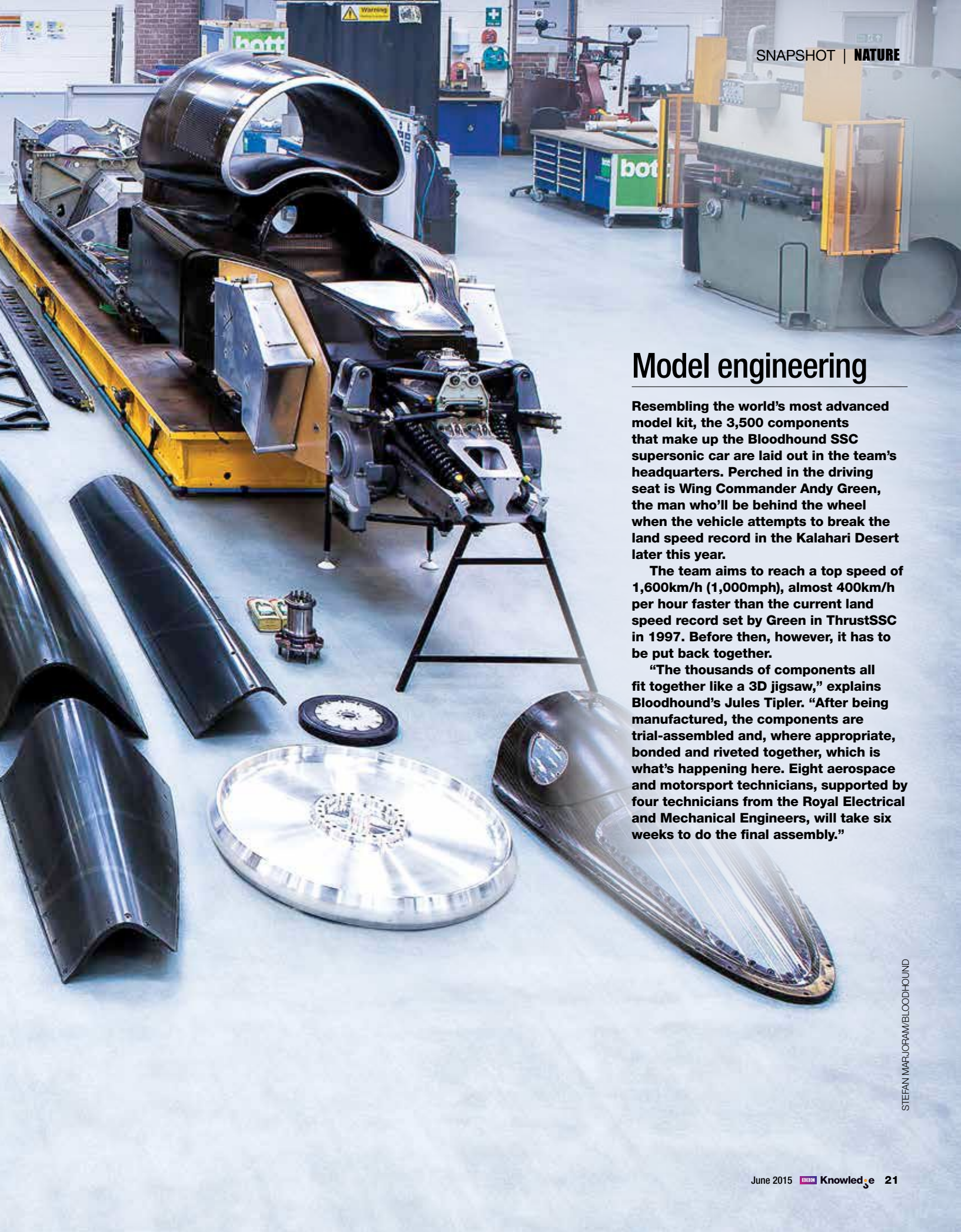
Resembling a clutch of giant eggs, Britain's latest helium-filled airship, Airlander 10, sits in a cavernous hanger at RAF Cardington. Despite being the world's longest aircraft at 92m (302ft) in length, the vessel is surprisingly agile. It is able to take off and land from any flat surface, including water, sand and ice, and can carry loads exceeding 10 tonnes. It can attain speeds of 110-130km/h (68-81mph).

"It flies and floats like an airship, its unique hull shape creates aerodynamic lift like an aeroplane, and its engines can rotate and push air out at any angle, allowing it to hover and be controlled like a helicopter," explains Chris Daniels at Hybrid Air Vehicles, the company responsible for its design. "This makes it an exceptionally efficient and versatile aircraft, with endurance measured in weeks, rather than days."

It could potentially be used for search-and-rescue missions, luxury cruises, or carrying freight to remote locations such as oil rigs, the company says. Test flights are scheduled for later this year.

GETTY





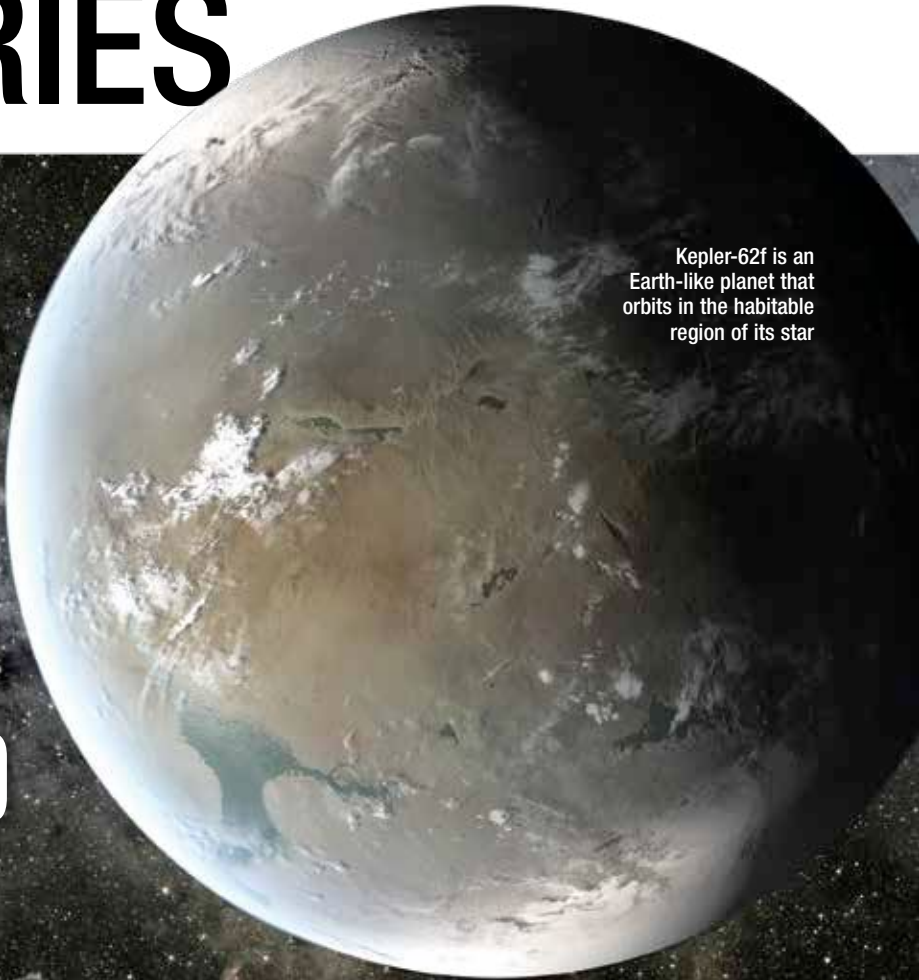
Model engineering

Resembling the world's most advanced model kit, the 3,500 components that make up the Bloodhound SSC supersonic car are laid out in the team's headquarters. Perched in the driving seat is Wing Commander Andy Green, the man who'll be behind the wheel when the vehicle attempts to break the land speed record in the Kalahari Desert later this year.

The team aims to reach a top speed of 1,600km/h (1,000mph), almost 400km/h per hour faster than the current land speed record set by Green in ThrustSSC in 1997. Before then, however, it has to be put back together.

"The thousands of components all fit together like a 3D jigsaw," explains Bloodhound's Jules Tipler. "After being manufactured, the components are trial-assembled and, where appropriate, bonded and riveted together, which is what's happening here. Eight aerospace and motorsport technicians, supported by four technicians from the Royal Electrical and Mechanical Engineers, will take six weeks to do the final assembly."

DISCOVERIES



Kepler-62f is an Earth-like planet that orbits in the habitable region of its star

WHY THERE'S AN EARTH-LIKE PLANET AROUND EVERY STAR

Planetary scientists have calculated that there are billions of Earth-like planets in our galaxy that could potentially support life.

A team at the Australian National University made the calculation using the Titius-Bode law, along with knowledge of the thousands of exoplanets that have been discovered by the Kepler Space Telescope.

The Titius-Bode law was created 200 years ago and can be used to predict the positions of planets orbiting a star. Due to the method used to spot them, the Kepler Space Telescope is more likely

to find planets that are very close to their stars. Using the Kepler data as a starting point, they then applied the Titius-Bode law to predict the existence of planets further away from their stars.

They found that the standard star has roughly two planets in the so-called Goldilocks zone. This is the distance from the star where liquid water, crucial for life, can exist. If the calculation is correct, it would mean there are 200 billion Earth-like planets in the Milky Way alone.

But don't get too excited just yet. The university research team says it is highly unlikely that these

exoplanets are home to thriving alien civilisations.

"The ingredients for life are plentiful, and we now know that habitable environments are plentiful," says researcher Dr Charley Lineweaver. "However, the Universe is not teeming with aliens with human-like intelligence that can build radio telescopes and spaceships. Otherwise we would have seen or heard from them. It could be that there is some other bottleneck for the emergence of life that we haven't worked out yet. Or intelligent civilisations evolve, but then self-destruct."

HEALTH

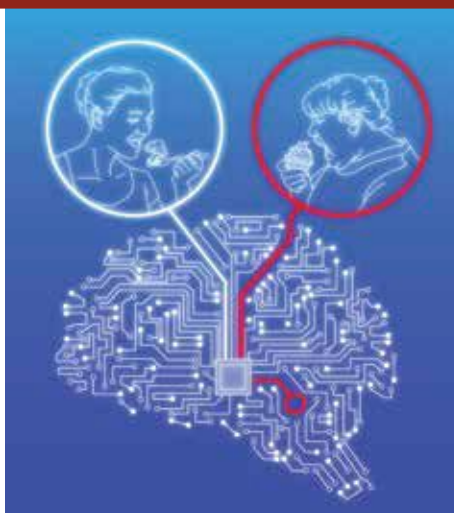
Overeating solved?

If your sweet tooth is causing you to pile on the pounds, you may want to read on. Researchers at MIT have identified a neural circuit that controls compulsive sugar consumption.

Compulsive overeating is a reward-seeking behaviour that's similar to drug addiction. But because eating is needed for survival, any successful therapies need to separate the neural mechanisms that cause overeating from those responsible for normal eating.

The team found success when manipulating a neural pathway connecting the lateral hypothalamus, an area of the brain involved in hunger, to the ventral tegmental area, which is involved with the brain's natural reward circuitry.

Activating this pathway caused well-fed mice to spend more time eating. It also increased their consumption of a sugar solution placed separately from their food, even when they had to cross an electrified



platform to reach it. Inhibiting this pathway in hungry mice reduced the sugar-seeking behaviour without decreasing normal food consumption.

"Our findings are exciting because they raise the possibility that we could develop a treatment that selectively curbs compulsive overeating without altering healthy eating behaviour", says author Dr Kay Tye,

PALAEONTOLOGY

Here be dragons

There can be few mythical beasts as synonymous with their country of origin as the dragon is with China. Now, palaeontologists have discovered a new species of dinosaur that resembles the legendary creature.

Qijianglong, meaning 'the dragon of Qijiang', was found at a fossil site first discovered by construction workers in 2006. It's about 15 metres long and lived 160 million years ago in the Late Jurassic. It belongs to a group of dinosaurs called the *mamenchisaurids*. These are unique to Asia and are known for their enormous necks, which can measure up to half their total length.

"*Qijianglong* is a cool animal. If you imagine a big animal that is half neck, you can see that evolution can do quite extraordinary things," says the University of Alberta's Tetsuto Miyashita. "It is rare to find a head and neck of a long-necked dinosaur together because the head is so small and is easily detached after the animal dies."

Upon inspection, *Qijianglong* was found to have neck vertebrae that were filled with air, which is a unique trait among *mamenchisaurids*. This made the neck light, despite its huge size. Interlocking joints between the vertebrae suggest that the neck was more flexible when bending vertically than sideways.

The skeleton has been housed in a museum in Qijiang. "China is home to the ancient myths of dragons," says Miyashita. "I wonder if the ancient Chinese stumbled upon a skeleton of a long-necked dinosaur like *Qijianglong* and pictured that mythical creature."

GOOD MONTH/ BAD MONTH

It's been good for: THOSE WITH A SENSE OF PURPOSE

Do you spring out of bed in the morning, excited about all the possibilities the day will bring? If so, lucky you – a study at Mount Sinai Medical Center has found that those with a strong sense of direction and a feeling that life is worth living are 23 per cent less likely to die from all causes than listless counterparts.

MODERATE DRINKERS



If you are on the hunt for a new partner, drinking a moderate amount of alcohol may help. Imbibing one 250ml glass of wine made the drinker appear more attractive,

according to a University of Bristol study. It is thought the effect is due to small changes in appearance such as facial flushing.

It's been bad for: HIPSTERS



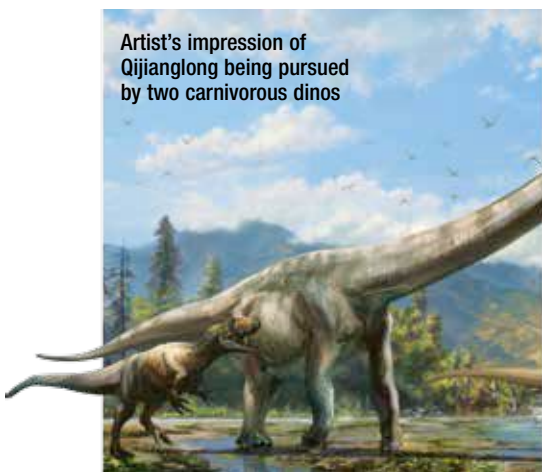
Anyone under the impression that their topknot, sailor tattoos and ironic facial hair are an outward expression of their individuality might want to think again. Mathematician Paul

Smaldino has created a model that shows that even if we try to be different, human behaviour always tends towards 'collective conformity'. It's why hipsters inevitably all end up looking the same, he says.

THE SHORT-TEMPERED

If you have a short fuse, there's more reason than ever to consider new ways of calming down. The risk of a heart attack can be up to eight times higher in the two hours following an intense burst of anger, a study at the University of Sydney has found.

Artist's impression of *Qijianglong* being pursued by two carnivorous dinos



10 DISCOVERIES THAT WILL SHAPE THE FUTURE

10 Temporary tattoo to measure blood glucose

It seems tattoos may no longer be the preserve of footballers, rappers and hipsters. A group at the University of California has created a temporary paper-based tattoo that measures blood glucose levels using a mild electric shock.

The technology could replace the current finger-prick method.

Take a blood test without the need for a needle

9 Compound in wine may aid memory

Resveratrol, an antioxidant found in the skin of red grapes, as well as in red wine, may help to **prevent age-related memory decline**. Researchers at Texas A&M University found that rats treated with the compound showed improved spatial learning and memory, and double the rate of growth of new neurones.

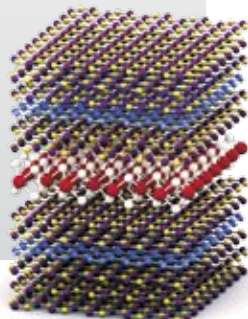


A little red wine now and then may improve your memory; a lot in one go will cause memory loss the next morning...

8 Graphene LEDs

Graphene could enable engineers to create the first generation of semi-transparent devices, according to research at the University of Manchester. The team constructed LEDs by combining different 2D crystals of graphene. **The tech**

could be used in everything from simple lighting to lasers and flexible displays. The components are just 10-40 atoms thick and emit light across their whole surface.



7 Stem cell treatment to reverse baldness

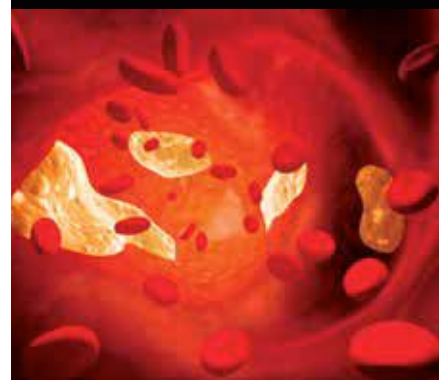


American researchers have turned stem cells into the cells that control hair growth

Going a bit thin on top? Fear not, **a team in the US has successfully used human pluripotent stem cells to generate new hair**. They coaxed the stem cells to become dermal papillae, which are cells that regulate hair follicle formation and growth. The treatment has been successful in rats, and the researchers now hope to try it in humans too.

6 Drug preserves brain function after stroke

Retigabine, a drug currently used for treating epilepsy, could **significantly reduce the debilitating effects of strokes**. A team in Texas found that the drug greatly reduced damage to brain tissue when tested in mice that had suffered strokes. It also helped to preserve motor functions such as balance and coordination.



5

Liquid sunshine

The fuel in your car may one day be produced by genetically modified bacteria. Harvard scientists have designed a system that uses an 'electric leaf' to liberate hydrogen from water using sunlight. The bacterium *Ralstonia eutropha* then absorbs the hydrogen and **combines it with carbon dioxide to create the liquid fuel**, isopropanol.

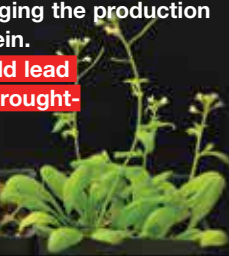
3

Drought-tolerant plants

Humans are not the only ones struggling with the effects of climate change – plants are too. Help may be on the way, as researchers in California have used synthetic biology techniques to help plants conserve water by encouraging the production of a specific protein.

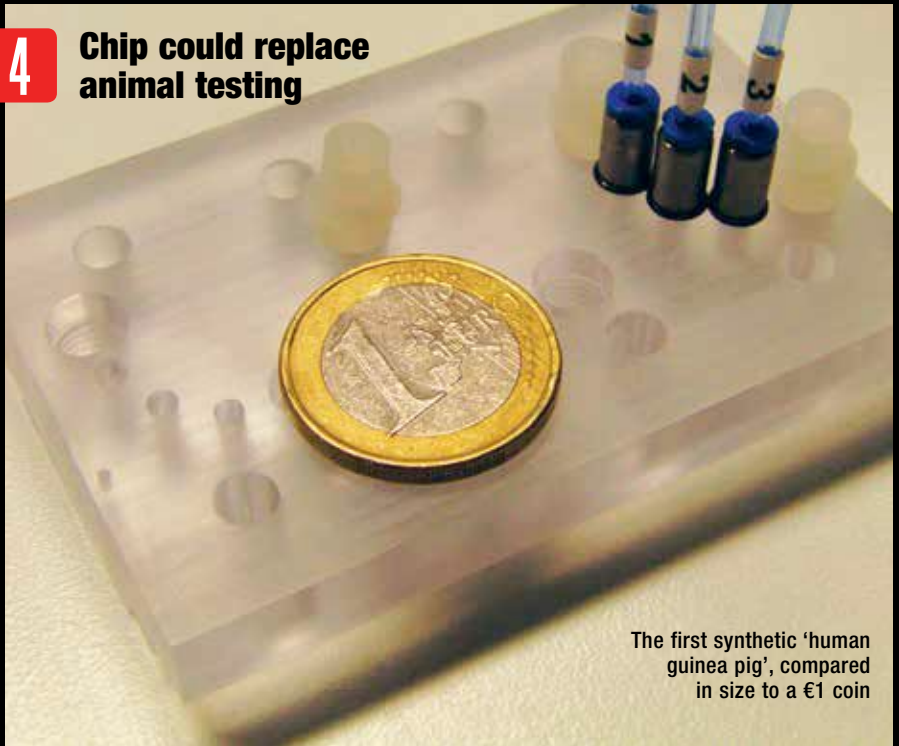
The research could lead to hardier, more drought-resistant plants.

Hardier plants could soon be arriving in our gardens



4

Chip could replace animal testing



The first synthetic 'human guinea pig', compared in size to a €1 coin

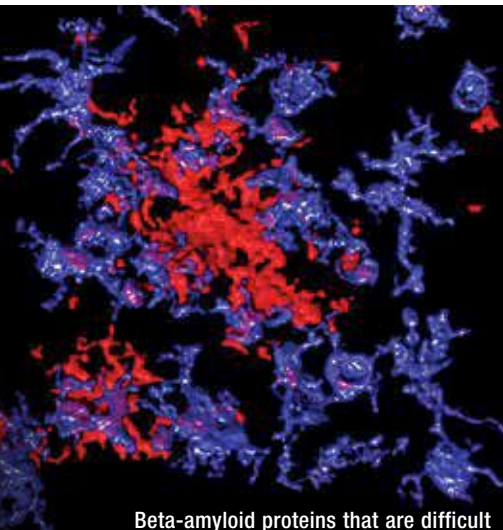
A team in Berlin has produced a multi-organ chip that could **reduce the need for animal testing**. Cells from various organs can be placed in the chip and

used to simulate processes that occur within the human body. The substance to be tested is then introduced into the chip and its effects are monitored.

2

Immune cells may help fight Alzheimer's

Alzheimer's disease is an irreversible, progressive brain disease that causes problems with memory, thinking and behaviour. Brains with Alzheimer's disease show build-up of a sticky plaque. This is made of a protein called beta-amyloid and induces memory loss. A team in California has found that inhibiting a substance called interleukin-10 in mice activates an immune response to clear the brain of plaques, restoring brain cells that were damaged. **The work could lead to more effective human therapies.**



Beta-amyloid proteins that are difficult to break down can accumulate in the brain and lead to Alzheimer's

1

Intelligent keyboard

Always forgetting your passwords? There may soon be a solution. Engineers at the Georgia Institute of Technology have created a keyboard that can identify users by their typing style. The keyboard is capable of recording key strokes to create a profile for users. **It could be used instead of, or as well as, regular passwords for security.**



This new 'smart' keyboard recognises your typing

PATENTLY OBVIOUS

WITH JAMES LLOYD

Inventions and discoveries that will change the world

Silent movies



The music swells and a roomful of cinemagoers grip their seats as the hero moves in for a kiss. His dewy-eyed lover gazes back, and then... rrrrrnnng! It's your phone, and now the whole cinema is looking your way. A new patent from Microsoft promises to make inopportune phone calls a thing of the past. The technology will put your phone into 'inconspicuous mode' when you're in the cinema, disabling the sound and dimming the screen so you

don't disturb your fellow popcorn-munchers. Microsoft's system will automatically detect when you're at the movies, by monitoring your GPS location, checking your calendar for cinema trips, noting details of tickets bought online, or even sensing changes in light levels. It could also be used in meetings, the bedroom or on public transport, meaning you'll never be ejected from the Quiet Coach again.

Patent number: US 8,934,879

Doze on demand

When chamomile tea doesn't do the trick, here's a new way to help you drop off: Sprayable Sleep. Developed by a team in the US and contains just three ingredients: water, tyrosine (an amino acid) and melatonin – the hormone that regulates our circadian rhythms and is often used to treat sleeping disorders. Once in contact with the skin, Sprayable Sleep is absorbed by the body, providing a release of melatonin that the makers say gives a natural-feeling sleep without the grogginess often associated with sleeping pills.

Patent pending

Pocket power

Are your gadgets always running out of juice? A portable power generator could be the solution. Kraftwerk is a lightweight device that uses fuel cell tech to convert camping gas into electrical power. Developed by materials scientist Dr Sascha Kühn, the device is capable of charging 11 iPhones with just one load of gas. Using gas instead of batteries means that kraftwerk can be quickly refilled. As you don't need to be anywhere near a power socket, it's a perfect solution for those camping trips.

Patent pending

WEB CLICKS

OUR PICK OF INTERNET HIGHLIGHTS TO EXPLORE

Andromeda Bot

Twitter.com/AndromedaBot



Hubble released the largest ever photo of the Andromeda galaxy in January 2015. This Twitter account tweets a new section of the picture every hour, allowing you to see individual stars in all their glory. According to the European Space Agency, you'd need over 600 HD TV screens to display the image in full.

Edible Education

Food.berkeley.edu/edible-education-101/



Ever felt like you should know more about where your food comes from, and how it could be more sustainable? This lecture course at the University of California, Berkeley, is exploring those questions and more. The first lecture was on 26 January, but course materials are freely available online.

Jurassic World

Jurassicworld.com/dinosaurs/



Jurassic World is almost here, and if you want to brush up on your dinosaur knowledge, then look no further than the film's website. The jury is still out on exactly how scientifically accurate the film will be (the dinos in the trailer lacked feathers) but, either way, everyone's going to be talking about them come summer.

Brainwave

Http://bit.ly/1ESDRcT




The Open

Brainwave University's app consists of five games that test your cognitive ability. But this isn't your average brain-training

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all-India school quiz

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- Certificates & Performance Analysis Reports for all participants



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SEP. 23 & OCT. 8



18TH SOF NATIONAL SCIENCE OLYMPIAD

OCT. 20 & NOV. 5



9TH SOF INTERNATIONAL MATHEMATICS OLYMPIAD

NOV. 26 & DEC. 10



6TH SOF INTERNATIONAL ENGLISH OLYMPIAD

JAN. 20 & JAN. 28

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SCHOLARSHIPS

- Girl Child Scholarship Scheme -300 Nos. Rs. 5,000/ each
- Scholarship of Excellence in English-120 Nos. Rs. 5,000/ each
- Academic Excellence Scholarship - Rs 5000/+ Trophy - 160 Nos.

SCHEDULE OF EXAMS 2015-16

	Date: One	Date: Two
15 th National Cyber Olympiad (NCO)	23 rd September	8 th October
18 th National Science Olympiad (NSO)	20 th October	5 th November
9 th International Mathematics Olympiad (IMO)	26 th November	10 th December
6 th International English Olympiad (IEO)	20 th January	28 th January

AWARDS & SCHOLARSHIPS

AT INTERNATIONAL LEVEL

- Rank 1** 47 winners - Scholarship of Rs 50,000/ each + Gold medals + Merit Certificates.
- Rank 2** 47 winners - Scholarship of Rs 25,000/ each + Silver medals + Merit Certificates.
- Rank 3** 47 winners - Scholarship of Rs 10,000/ each + Bronze medals + Merit Certificates.

AT SCHOOL LEVEL

6,00,000 Medals to School toppers.
Student Performance Report (SPR) and Participation Certificates for all participants.
Merit Certificates for all 2nd level participants.

AT STATE / ZONAL LEVEL

- Rank 1** 940 winners - Scholarship of Rs 5,000/ each + Gold medals + Merit Certificates.
- Rank 2** 940 winners - Scholarship of Rs 2,500/ each + Silver medals + Merit Certificates.
- Rank 3** 940 winners - Scholarship of Rs 1,000/ each + Bronze medals + Merit Certificates.
- Rank 4-25** 20680 winners - Gifts worth Rs 1000/ each + Merit Certificates.
- 25000 Medals of Excellence & Certificates of Excellence to top 25 rank holders in first level exams.

SCHOLARSHIPS

Girl Child Scholarship Scheme (GCSS) - 300 Nos

₹ 5,000/- each scholarship to 300 girls will be provided. school may nominate one girl who is academically inclined and is from an economically weak family.

Scholarship for Excellence in English (SEE) - 120 Nos

₹ 5,000/- each scholarship to 120 students will be provided. School may nominate one student excelling in English language.

SOF – Academic Excellence Scholarship (AES) - 160 Nos

₹ 5000/ scholarship + Trophy to 160 students from class three to class ten. Winner will be a student who gets highest aggregate score in any three Olympiad exams in the 2nd level (1st level for IEO).



A bust of Gaius Julius Caesar. By March 44 BC, the great general had made some powerful enemies by increasingly acting like a monarch

For centuries we've been told that two Roman senators called Brutus and Cassius masterminded the plot to butcher Julius Caesar on the Ides of March. But is that the whole story? Did the brains behind the conspiracy reside somewhere else entirely – with one of Caesar's greatest allies?

Barry Strauss finds out

“What do you say, Caesar? Will someone of your stature pay attention to the dreams of a woman and the omens of foolish men?” So said Decimus Junius Brutus Albinus to Gaius Julius Caesar. The 36-year-old Decimus spoke frankly to a man his elder by nearly 20 years, a man who was not only his chief but also Rome's Dictator for Life. Yet Caesar was fond of Decimus, a longtime comrade-in-arms and a trusted lieutenant, and so he let him speak. They met in Caesar's official residence in the heart of Rome.

It was the morning of 15 March 44 BC – the Ides, as the Romans called the approximate middle of each month: the Ides of March. The Senate was in session that day, its members eagerly awaiting the dictator's arrival. Yet Caesar had decided not to attend – allegedly because of bad health but, in fact, the real cause was a series of ill omens that had terrified his wife, Calpurnia.

Decimus changed Caesar's mind. Caesar decided to go to the Senate meeting after all, if only to announce a postponement in person. What he didn't know was that more than 60 conspirators were waiting for him there, their daggers ready. Decimus, however, was all too aware – he was one of the plots' ringleaders, and his actions that morning were about to change the course of history.

Despite this, most historians have traditionally cast Brutus and Cassius as the brains behind the conspiracy. In doing so, they've followed the lead of Plutarch, who wrote 150 years after the assassination, and

Shakespeare, who drew most of his story from Plutarch. They tend to omit Decimus, who Shakespeare misnames 'Decius' and mentions only in the scene described above. Yet Decimus was key. His motives are less opaque than most think and his behaviour shows just how well organised the conspirators were.

The earliest surviving, detailed source for Caesar's assassination makes Decimus *the*

leader of the conspiracy. Sometime within a few decades of the Ides of March, Nicolaus of Damascus, a scholar and bureaucrat, wrote a *Life of Caesar Augustus* – that is, of Augustus, Rome's first emperor (reigned 27 BC–AD 14). A later abridgment of this work survives and it focuses on the assassination.

Until recently, scholars have tended to dismiss Nicolaus because he worked for Augustus and so had a motive to attack the conspirators. But recent work suggests that Nicolaus was a brilliant student of human nature who deserves more attention. A series of letters between Decimus and Cicero, all written after the assassination, also shed light on the plot, but they too have been neglected.

Things turn sour

Unlike Brutus and Cassius, Decimus was Caesar's man. In the civil war between Caesar and the Roman general Pompey (49–45 BC), Brutus and Cassius both supported Pompey and then later changed sides. By contrast, Decimus backed Caesar from start to finish. During the conflict, Caesar appointed Decimus as his lieutenant to govern Gaul in his absence. At the war's end in 45 BC, Decimus left Gaul and returned to Italy with Caesar.

Then things turned sour. Between September 45 BC and March 44 BC Decimus changed his mind about Caesar. We don't know why but it probably had more to do with power than principle. Decimus's letters to Cicero reveal a polite if terse man of action with a keen sense of

IN CONTEXT

Caesar

By 44 BC Gaius Julius Caesar was the most famous and controversial man in Rome. A populist political star and great writer, he excelled in the military realm as well, pulling off a lightning conquest of Gaul – roughly, France and Belgium – as well as invading Britain and Germany (58–50 BC). When his enemies, the old guard in the Senate, removed him from command, Caesar invaded Italy. He went on to total victory in a civil war (49–45 BC) that ranged across the Mediterranean. His challenge now was to reconcile his surviving enemies and to convince staunch republicans to accept his power as dictator. It was a daunting task.

Caesar's killers used the pugio dagger, like the one shown here, as it was easy to smuggle into the Senate House





A posse of senators stab Caesar to death in Vincenzo Camuccini's painting, completed in c1798. The plot succeeded, says Barry Strauss, because it was planned with military precision: after isolating their victim, the assassins acted rapidly and ruthlessly

honour, a nose for betrayal, and a thirst for vengeance.

Perhaps what moved Decimus was the sight of the two triumphal parades in Rome in autumn 45 BC that Caesar allowed his lieutenants in Spain to celebrate, against all custom. Caesar did not, however, grant a similar privilege to Decimus for his victory over a fierce Gallic tribe.

Or perhaps it was Caesar's appointment of his grandnephew Octavian (as Augustus was then known) as his second-in-command in a new war in 44 BC against Parthia (roughly, ancient Iran), Rome's rival in the eastern Mediterranean. Decimus meanwhile had to stay behind and govern Italian Gaul.

Whatever his motives, once he turned on Caesar, Decimus was indispensable. He was both the plotters' chief of security and their leading spy. As the only conspirator in Caesar's inner circle, Decimus was a mole, able to report on what Caesar was thinking. What's more, Decimus controlled a troupe of gladiators, which played a key role on the Ides.

Caesar remained in Rome between October 45 and March 44 BC – his longest stay there for years. He never revealed a programme but his actions betrayed that he aimed to change Rome's government. He behaved in ever-more dictatorial ways, summed up in his adoption of the unprec-

edented title of Dictator for Life.

He maintained Rome's traditional republican magistracies but elections increasingly became mere formalities – Caesar had the real power of appointment. Consuls, praetors (magistrates) and senators saw power shifting to Caesar's secretaries and advisors – some of them had only recently become Roman citizens; some were even freedmen (former slaves). Caesar was not a king, but he had acquired the equivalent of royal power.

There was another issue at play here – the prospect of what would happen after Caesar's death. To his critics, the favour he showed to Octavian raised the terrifying prospect of a dynasty.

Some Romans responded to Caesar's growing power with flattery. They voted

him a long stream of honours including, most egregiously, naming him a god, with plans afoot for priests and a temple. Others, however, decided that he had to be stopped, and so they decided on assassination. True, they acted in the name of the Republic and liberty and against a budding monarchy but they also saw in his growing influence a threat to their own power and privilege.

Plans to assassinate Caesar are attested as early as the summer of 45 BC but the conspiracy that struck on the Ides of March did not gel until February 44 BC. At least 60 men joined it (of whom we can identify just 20 today – and some of them are little more than names). According to a later writer, Seneca, the majority of the conspirators were not Caesar's enemies – former allies of Pompey – but his friends and supporters.

That certainly can't be said for Brutus and Cassius, the best-known conspirators. Cassius was a military man and a former Pompey supporter who despised Caesar's dictatorial ways. As for Brutus, he was hardly the friend of Caesar whom Shakespeare depicts.

Brutus's mother was Caesar's former mistress. However, Brutus supported Pompey until the latter lost to Caesar on the battlefield in 48 BC, at which point Brutus switched sides. He promptly betrayed his ex-chief by providing Caesar intelligence

“Decimus was the plotters' chief of security, and their leading spy. He was able to report on what Caesar was thinking”

about the likely whereabouts of Pompey, who had escaped after the battle. Afterwards, Caesar rewarded Brutus with high office.

This, however, was to prove the high point of Caesar and Brutus's relationship. In the summer of 45 BC, Brutus divorced his wife and remarried. His new bride was Porcia, his cousin and, far more pertinently to this story, daughter of Caesar's late archenemy Cato.

Crucially, in the winter of 44 BC, Caesar's opponents began calling on Brutus to uphold the tradition of his ancestors, who included the founder of the Roman Republic, Lucius Junius Brutus, the man who had led the expulsion of Rome's kings hundreds of years earlier. And so, through a combination of pride, principle – and, perhaps, love for his wife – Brutus turned on Caesar.

Military precision

The plot to assassinate Caesar succeeded because it was meticulously planned, and flawlessly executed. With generals such as Decimus, Cassius and Caesar's veteran commander Trebonius involved, one would expect nothing less than military precision. The assassins chose to end Caesar's life themselves rather than by hiring killers – a decision that showed their seriousness of purpose. And by striking at a Senate meeting they made it a public act rather than a private vendetta – an assassination and not a murder.

That this was a professional operation is even reflected in the killers' choice of weapon. Caesar's assassins attacked him with daggers and not, as is sometimes imagined, with swords. The latter were too big to sneak into the Senate House and too unwieldy for use in close quarters. In particular, the killers used a military dagger (the *pugio*), which was becoming standard issue for legionaries.

Military daggers were not only practical weapons but also honourable ones. Caesar's supporters later called the assassins common criminals and accused them of using *sicae*, a short, curved blade that had the negative connotation of a switchblade or flick knife. So, in 44 BC, Brutus issued a coin that celebrated the Ides of March with two military daggers. Again, he wanted to show that the assassins were no mere murderers.

The Roman Senate House still stands in the Roman Forum and most visitors assume that Caesar was killed there – but he was not, nor on the Capitoline Hill, as Shakespeare states. The assassination took place about half a mile away from the Forum in Pompey's

“Before the end, Caesar wrapped his toga around his face and fell at the foot of the statue of his great rival, Pompey”

Senate House, ironically built by Caesar's great rival. It was part of a huge complex including a theatre, a park, a covered portico, and shops and offices. Gladiatorial games took place in the theatre on the Ides of March, which gave Decimus an excuse for deploying his gladiators near Pompey's Senate House. Their real purpose was as a backup security force.

As a general, Caesar had a bodyguard but he made a point of dismissing it after returning to civilian life in Rome. He wanted to seem accessible and fearless. What's more, only senators could enter a Senate meeting, so most of Caesar's retinue would have had to remain outside the building. This made the dictator uniquely vulnerable inside the Senate House. Still, Caesar had appointed many of the senators personally, and they included military men. If they came to Caesar's aid, they could overwhelm the assassins.

The assassins' response to this threat was to attack at speed, isolating their target before striking. Even before Caesar took his seat on the tribunal, several assassins stood behind

the chair while others surrounded him as if trying to grab his attention. The truth is that they were forming a perimeter.

Then the attack sprang into action. Tillius Cimber, a hard-drinking scrapper of a soldier whom Caesar favoured, held his hands out disrespectfully and pulled at Caesar's toga. At this signal, his co-conspirators struck, led by Publius Servilius Casca.

Caesar immediately called out to Cimber, “Why, this is violence”, and hurled an oath at Casca, labelling him either “impious” or “accursed”. However, he never said: “Et tu, Brute?” (“You too, Brutus?”) – that phrase is a Renaissance invention. Ancient authors report a rumour that Caesar said to Brutus, in Greek: “You too, child.” But they doubt that he even said that.

Caesar, the old warrior, tried to fight back. He stabbed Casca with his *stylus* – a small, pointed, iron writing utensil – and managed to get back up. Two of his supporters among the senators, Lucius Marcius Censorinus and Gaius Calvisius Sabinus, then attempted to reach him but the conspirators blocked their way, and forced them to flee.

Meanwhile, Trebonius had been assigned to buttonhole his old comrade Mark Antony and engage him in conversation outside the Senate's door. Antony was a veteran soldier, strong, dangerous and loyal to Caesar. If he'd entered the Senate room, he would have sat on the tribunal with Caesar and could have come to his aid.

With Mark Antony detained by Trebonius, there was little Caesar could do to defend himself. It probably took only minutes for him to die – succumbing to what most of the sources state were 23 wounds. Before the end, he wrapped his toga around his face and, in an ironic turn of events, fell at the foot of a statue of his rival, Pompey.

For all its brilliance, the plot to kill Caesar didn't prove the panacea that the assassins hoped. Civil war soon broke out again and, to a man, they were to suffer violent deaths. What's more, the Republic that they aimed to defend perished and gave way to an empire. That, however, does not brand them as foolish idealists. It merely shows that their political acumen did not match the military skill they displayed on the Ides of March. 📌



This coin, issued by Brutus, one of the plot's ringleaders, displays the military daggers employed against Caesar

Barry Strauss is a professor of history and classics at Cornell University. His latest book, *The Death of Caesar: The Story of History's Most Famous Assassination*, is published by Simon & Schuster this month.





HOW BACTERIA CHANGE YOUR MOOD

Tiny organisms in your gut may be messing with your mind.

Nicola Davis lifts the lid on this new area of research

Bacteria. For many it's a dirty word, suggesting a collection of invaders to be obliterated with a lemon-fresh spray. Yet the staggering truth is that you are more bacteria than body – the gut alone holds over 100 trillion bacteria of myriad species, many of which help with breaking down food and play a vital role in immunity. In fact, you've been friends for a while. Most of your gut microbiota (including bacteria) initially came from your mother's birth canal as you entered the world, or from skin and the surrounding environment if you were born by caesarean. Once you're out in the open, multiple factors such as diet, antibiotics, genetics and stress ►



will influence the microbiota. The upshot is a cornucopia of bugs that weighs about the same as a human brain. And perhaps that's fitting, for while it's long been known that the brain can influence the gut, modern science is showing that communication can go both ways. Indeed, recent studies have revealed that the gut microbiota could be involved in a host of conditions such as obesity, social behaviour deficits, Parkinson's disease and anxiety. That's right – microbes might be meddling with your mood.

It's a hot topic of research that exploded just 10 years ago when a team of Japanese researchers delved into the gut microbiota of mice. But these weren't any old mice. They were raised in a sterile environment, therefore making them 'germ-free'. This created a clean slate with which to study the brain and behaviour before and after bacterial colonisation. Surprisingly, the researchers found that the germ-free mice had greater amounts of stress-related hormones when restrained than animals with microbes. Yet when young germ-free mice were colonised by certain bacteria, their stress response changed. What's more, the germ-free mice also showed differences in the levels of a brain-derived neurotrophic factor (BDNF) protein – a substance in the brain that affects the survival, growth and connection of neurones (brain cells).

“Studies have revealed that the gut microbiota could be involved in a host of conditions”

A wave of research involving germ-free mice followed. One particularly intriguing study was carried out by Dr Jane Foster and her colleagues from McMaster University in Canada. Using a cross-shaped maze, they found that germ-free mice spent more time hanging out in exposed areas than their bugged-up peers. This suggested reduced levels of anxiety, despite having increased levels of a stress-related hormone. Furthermore, the germ-free mice showed changes to the levels of BDNF-encoding molecules, which suggests the gut microbiota might tinker with how the brain is wired for anxiety. “We know what brain regions are involved, and what's interesting is those brain regions are changed in these manipulations of microbiota,” says Foster.

The interesting relationship between microbiota and behaviour, however, is far from simple. Changes to levels of BDNF-encoding molecules appear to differ between sexes. Meanwhile, a recent study using one strain of rat found that the animals actually appeared to behave in a more anxious way when they didn't have gut microbiota. Studies have also found that infecting mice with populations of ‘bad’ bacteria can increase their anxious demeanour.

Bugging out

Nevertheless, the notion that bugs can affect behaviour is pretty mind-boggling. In one of the most astonishing studies, a team of researchers transferred gut microbes from an anxious strain of mouse into a germ-free mouse of a more adventurous strain – and vice versa. The result? A behaviour transplant.

Yet questions abound, especially regarding the



Above: Intestinal bacteria help us to digest food and absorb nutrients

Left: Prof John Cryan is studying the other effects these microscopic organisms have on our physiology



MARTIN OEGGERLI, CLARE KEOGH/UNIVERSITY COLLEGE CORK





significance of age. Indeed, some studies suggest that stress responses and anxiety levels in germ-free mice can only be altered by colonisation with bacteria if such exposure occurs when the animals are young. If the same effect is observed in humans, it could imply a need for interventions in childhood and pre-adolescence. Interestingly, the composition of our own gut microbiota is unstable until we reach about three years of age. “It’s just developing, and that is also the same period of life when the brain is developing,” states Prof Emeran Mayer, a gastroenterologist at the University of California, Los Angeles.

Interventions in elderly people might also be important because our gut bacteria levels naturally start to decline as we age. “The microbiota composition, diversity [and] abundance kind of reverses back to the way it was in childhood,” says Mayer. “So again it’s quite possible that any manipulations or any influence on brain function will be greater at that time.”

Exactly how the gut microbiota bring about

100
trillion bacteria are
found in the gut



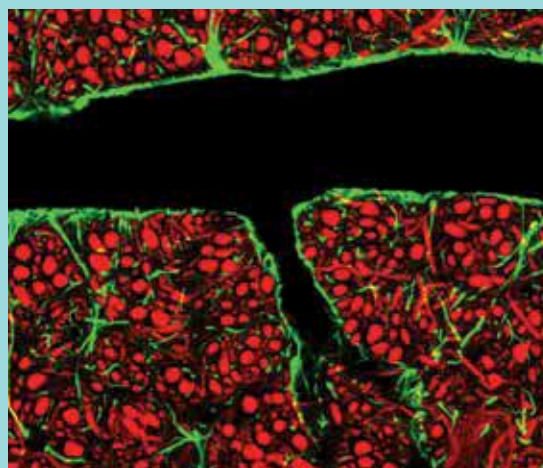
changes to the brain and behaviour is far from clear-cut. “If I have a headache it could be because I bumped my head, or it could be because I am dehydrated. Those are two very different mechanisms where the readout is the same,” says Foster. “It is the same thing here.”

And the mechanisms are myriad. Among the mooted possibilities, gut bacteria – or the molecules they produce – could directly or indirectly interact with branches of the vagus nerve in the gut. They could signal to the brain, affect hormonal signalling routes, interact with the immune system or trigger responses via pathways that include neurones within the gut lining and the vagus nerve. What’s more, just a few months ago, researchers revealed that the gut microbiota could affect the permeability of the blood-brain barrier. It’s a web of intrigue.

Mood swings

“There are so many different types of bacteria and they are all having very different effects on





different aspects of physiology,” says Prof John Cryan from the University of Cork.

In one study, scientists at McMaster University joined forces with Cryan and his team to probe the impact of the probiotic *Lactobacillus rhamnosus* on healthy mice. “It dampened down anxiety and made the animals more chilled out [and] changed the brain chemistry,” Cryan explains. “When we cut the vagus nerve this didn’t happen.” But complexities are never far away. “Some of our colleagues in Canada have done similar studies with different bacteria and showed that it wasn’t dependent on the vagus,” he adds.

It’s a problem worth probing. While human studies are few and far between, there is a tantalising suggestion that various *Bifidobacteria* and *Lactobacillus* species might influence mood in humans as well as rodents. In one trial, healthy people given a blend of such probiotics for 30 days were found to fare better in questionnaires probing anxiety, depression and stress than those who were given a placebo. But that doesn’t mean we should be stocking our shelves with probiotics just yet. “For me, taking a probiotic is like saying I’ll take a drug,” says Cryan. “You might take a statin for cardiovascular disease, but you wouldn’t take it if you had depression – that’s where we are with probiotics. We need to get more precise about which bacteria are doing what and why.”

“The probiotic group showed a decrease in the activity of brain regions involved in emotion and sensation”

Clockwise from top: Brain-derived neurotrophic factor (BDNF); section through a blood vessel in the brain; germ-free mouse taking part in a study to monitor stress hormones

3
micrometres is
the size of a
Lactobacillus cell



Of mice and men

While it is still early days, Cryan foresees a future of ‘psychobiotics’ – probiotics that could be prescribed to help treat people who are suffering from mental health conditions. Taking substances that promote the presence of ‘good’ gut bacteria, known as prebiotics, might also prove beneficial.

“I think down the road there is a lot of hope that people will, in addition to getting their blood taken when they go to their GP, also get a quick snapshot of what’s going on in their microbiome,” states Cryan. That, he believes, could lead to the prescription of probiotics, perhaps in parallel to various other treatments.

Foster is cautious. “Until we have some evidence that the microbiome is different in different mental health disorders – and how it is different – we can’t really talk about how relevant what we are learning in the mouse is to people,” she explains. There are significant differences between mice and men, including the fact that the human brain boasts a very different prefrontal cortex to that of a rodent. This will affect the ways in which the gut microbiota may function. “If your microbiota send a signal to lower lying brain areas, the mouse doesn’t have much to compensate for that and it exhibits a particular behaviour,” says Mayer.

“In humans, these layers of prefrontal cortex can compensate and make up for it.”

As Mayer has found, gut bacteria do appear to have some impact on the human brain. In one small study funded by dairy product manufacturer Danone, Mayer's team split a cohort of healthy women into three groups. One group was given a probiotic yoghurt, one a probiotic-free dairy product and the other nothing at all. The women's brains were scanned using functional magnetic resonance imaging (fMRI) at the start of the experiment, then again after four weeks of taking the intervention. The study found that there were differences between the three groups in the connectivity of various brain regions when resting. But when the women were asked to match images of angry or frightened faces to similar pictures, the probiotic group showed a decrease in the activity of brain regions involved in emotion and sensation. It was a surprise. “I didn't expect it,” says Mayer candidly. “I was a sceptic in the beginning of all these animal studies. They just seemed too outlandish – it seemed like it just didn't fit into our paradigm of brain-gut interactions.” But, he points out, there's more to do. “It would be nice to repeat a study like the one we did, possibly in a population with anxiety so that we can determine [whether] these brain changes seen with the probiotic are also correlated with subjective changes in anxiety.”

Just how big an influence microbes have over our mood has yet to be determined, but Cryan believes we might be surprised. “It's worth considering that they are the master puppeteers,” he says. 🟡

Nicola davis is commissioning editor at *Observer Tech Monthly* and has a background in organic chemistry.



Lactobacillus casei (above) is found naturally in the human mouth and intestines. It is often added to yoghurts.

GUT FEELING

Probiotics and prebiotics have alleged health benefits for us. But what are the differences between them?

Prebiotics are substances that we cannot digest, but are believed to promote ‘good’ bacteria in the gut. Prebiotics occur naturally in some foods and include carbohydrates such as fructo-oligosaccharides, galacto-oligosaccharides and inulin.

Probiotics are live microbes that are thought to bring a health benefit. They are often administered as liquid drinks, yoghurts or tablets. Some of the most studied probiotics are of the genera *Lactobacillus* and *Bifidobacterium*.

The health benefits of probiotics are specific to each strain and different commercial products contain different strains of bacteria.

Commercial products in the EU are banned from using the label ‘probiotics’ as the health claims of such products have not been approved, but manufacturers are allowed to list the strain of bacteria included.

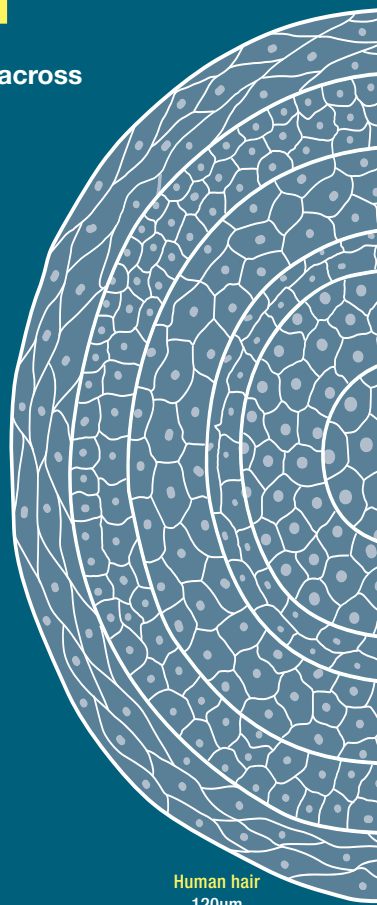
According to market researchers BCC Research, the global market for such products is expected to be worth around \$36.7bn (£24bn) by 2018.

SMALL BUT MIGHTY

Bacteria measure just a few micrometres across and are even smaller than red blood cells

Bacteria are typically made up of just a single cell each, but these cells are very different to those that make up the human body. Bacterial cells do not have a membrane-bound nucleus. And besides chromosomal DNA, bacteria can have ‘extra’ little loops of DNA called plasmids. They also lack membrane-bound organelles such as mitochondria – the ‘batteries’ of our own cells – and nearly all bacteria cells possess a cell wall.

Some bacteria are able to harness light energy, while others make use of chemical reactions involving organic or inorganic compounds to fuel processes in the cell. Bacterial cells are typically just a few micrometres (µm) in length. *Lactobacillus* cells, for example, are around 3µm long. Our own cells, however, can vary in size quite widely. Red blood cells are typically 7µm in diameter. And ova, the largest human cells, can reach 120µm – roughly the width of a human hair.



Lactobacillus
3µm

Red blood cell
7µm

Human hair
120µm

1 µm = 1 micrometre = 1 millionth of a metre

DATING TIPS FROM THE ANIMAL KINGDOM

Jennifer Verdolin says there is plenty we can learn about relationships from our furry, feathery and scaly friends...

Be picky

Periodically, well-meaning friends suggest that those who are still single should lower their standards and stop being so choosy. Yet most other species would squawk, growl and tweet in disagreement. Peahens, for instance, are very particular about what they look for in a peacock. Research led by behavioural ecologist Prof Marion Petrie found that peahens have a fondness for males with over 150 eyespots and evaluate an average of three males before making a decision. Being selective is possibly one of the most important pieces of guidance we can take from animals, even if that means it takes a while to find your best match.



1,2,3,4,5,6... let's just say you have over 150 spots and get on with it, yeah?



Sure, peacocks are pretty, but black-bellied wrens trounce them in a singing contest

Communicate clearly

Courtship, dating and relationships all require communication know-how. Miscommunication often comes down to individuals not listening to one another. Animals try hard to avoid miscommunication, and black-bellied wrens (pictured) are no exception. Research from the University of

Lethbridge illustrates that by listening and paying attention, black-bellied wrens are able to stay in-sync with their partner, anticipating exactly when to start singing so there is no overlap and no gap. If a conversation isn't going well, they take a break and try again later.



Make false promises, Mr Cockerel, and you'll be left with egg on your face!

Don't talk rubbish!

Actions speak louder than words. No one knows this better than hens. Dr Peter Marler, the late neurobiologist and animal communication researcher, showed that some cockerels will give out food calls even when there is no grub to be had. As hens are always on the

lookout for good sources of food, they come to check out what he claims to have. Should they arrive at the scene and discover that the cockerel can't offer what he said he could, they do not hesitate and move swiftly on. The bottom line? Talk is cheap – for cockerels as well as humans.



Little known fact: siamangs are the world's largest consumers of *Strepsils*

Assess interest

Dating and courtship takes effort, energy and resources. We know that many species engage in courtship feeding rituals. A study led by Dr Mariano Trillo found that not only does the *Paratrechalea ornata* spider male offer delicacies to females, but they also wrap them in an elaborate silk gift basket. The amount of energy an individual puts into courting and responding toward a potential mate is usually correlated with the degree of interest. Even seasoned romantic relationships require continued and equal investment by both parties. Thanks in part to research by the University of Michigan's Prof John Mitani, we know that socially monogamous siamangs (a type of gibbon, pictured left) wake up and sing a duet every single day, for the entire duration of their relationship. All relationships take work.

Set boundaries

Having limits on what we will accept isn't just important for people – it matters to animals, too. Sometimes, in those early stages of dating, we're more relaxed about our boundaries and will allow a potential partner to cross the line. Indeed, many of us resist the process of setting boundaries because we don't want to be rejected, to offend, or be seen as 'selfish'. Animals, however, have no such qualms. They establish boundaries quickly, they often say "no", and don't appear to feel the least bit bad about it.

Vampire bats (below) have cooperative natures, but research by Gerald Carter at the University of Maryland reveals that they are experts in how to give without becoming a doormat. They willingly share food with other group members, as long as those who receive give back in kind, regardless of the relationship status. However, they are not keen on other bats taking advantage, and will stop when their generosity is exploited. Knowing how, and when, to say "no" is vital in every relationship.



Despite their diet, vampire bats don't have a bloodsucking nature



Do French angelfish bicker over the washing-up?

Know what you want

Clarity of intention is another must. That means knowing where you are coming from and what you are currently looking for in the dating game. Are you in it for a minute?

A season? A lifetime? Whether you are an animal or a human, there are all sorts of different relationships out there.

Baboons have friends with benefits. Tuataras (a type of reptile from New Zealand) may switch partners every year. And French angelfish, like the ones pictured above, spend their entire lives with a single mate.

What you want out of any dating

experience may change depending on where you are in your life plan, your personality, who's sitting across the table from you, or even your genetics.

What animals teach us is that you can behave promiscuously like a squirrel, or you can act like a loyal French angelfish. It's not a moral judgment, it's about what works for you at the time – but you shouldn't pretend to be something you're not. 🍌

Dr Jennifer Verdolin is an animal behaviour expert and the author of *Wild Connection*.

SPECIAL REPORT

CLIMATE CHANGE:

PROBLEM SOLVED

It's not too late to save the planet: **Alistair Welch**
and **Max Mueller** investigate the technologies
that could make the biggest difference

Towards the end of 2014, the Intergovernmental Panel On Climate Change (IPCC) released its latest report, produced by over 800 scientists. It said the impact of climate change is far-reaching, both on the environment and on us. Changes linked to human activity include increases in extreme temperatures, high sea levels and heavy rain.

According to the IPCC, if climate change is left unchecked, global warming could be

irreversible by the time the 21st Century comes to a close.

But there is still hope. The IPCC says we can tackle the problem by cutting our emissions and investing in environmentally sound technologies, energy supplies and infrastructures. This, then, is *BBC Knowledge* magazine's very own guide to the ideas and technology that could do just that. Read on to find out how we'll save our planet.

“THE OPPORTUNITY OFFERED BY FLOATING SOLAR IS ESPECIALLY APPEALING IN COUNTRIES WHERE LAND IS AT A PREMIUM”

SET UP SOLAR FARMS AT SEA

There has been a recent drive to site solar farms in more adventurous locations to make the most of the formidable clean energy resource that is offered to us by the Sun's rays.

Such is the pull of solar power that in September 2014 the heirs to the Rockefeller fortune announced that they were to sell investments in fossil fuels. They want to reinvest in clean technology – solar photovoltaics in particular. It's an interesting departure, considering that the family made its fortune in the American oil industry.

Solar panels started on the rooftops and then moved into fields, but now developers are experimenting with constructing them on water. In September 2014, the UK's first floating solar array was built on a reservoir located on a Berkshire farm. The 200kW solar panel system will reduce the farm's energy bills as well as slash its carbon emissions.

In the UK, floating solar is attractive because deploying it avoids the criticism levelled at land-based projects that they waste valuable agricultural real estate. The opportunity offered by floating solar is especially appealing in countries where land availability is at a premium. Indeed, Japanese electronics manufacturer Kyocera recently announced plans to build the world's largest floating solar power plant. The installation is to include 11,000 PV panels over two lakes in Japan's Kato City. The sites would be capable of generating 2.9MW of electricity – enough to serve the requirements of nearly 1,000 homes.



Kyocera's proposed solar power plant would contain 11,000 PV panels

BUILD WIND FARMS IN THE SKY

Wind energy is taking off. Now the land and sea have been conquered, US scientists and engineers are looking to tackle the skies. Altaeros Energies, which is a spinout from the Massachusetts Institute of Technology, is currently developing a device that will generate energy from the strong, steady winds hundreds of metres above the Earth's surface.

The company hopes that its concept, the Buoyant Airborne Turbine (BAT), will be the world's first commercial aerial wind turbine. The device incorporates a three-blade horizontal axis wind turbine – the conventional configuration we are used to seeing in onshore and offshore turbines – held within an inflatable shell. When filled with helium, it floats into the air where it is held in place by

tethers at a maximum height of 600m (2,000 feet).

At this altitude, the wind power density is three times that found at 120 metres, which is the typical height of an

onshore wind turbine. The BAT features an autonomous control system that adjusts the device's direction and altitude to maximise its energy output. Electricity generated is transferred to a ground station by a connection in the tether. From here, it can be introduced to the grid or used to power equipment on site.

Initially, the company plans to develop a 30kW system with plans to scale up to 100 and 200kW devices. An array of ten 200kW BATs would thus have a similar capacity to a typical onshore wind turbine. And at a height of around 600m, it is unlikely to disrupt anyone's view of the landscape.

Altaeros is not the only player in the high altitude

wind game – a range of competitors with various ingenious technologies are also attempting to get their concepts off the ground.

Makani, which was acquired by Google in May 2013, is developing an 'Energy Kite' in an effort to capitalise on the wind resource at altitudes beyond the reach of conventional turbines. The kite is a tethered aerofoil that makes huge loops through the sky. As the wind rushes across the kite it rotates four mounted turbines. Meanwhile, Netherlands-based Ampyx Power is developing an auto-piloted glider that generates electricity as the tether fastening it to the ground station is extended.



The high-flying Buoyant Airborne Turbine captures more wind than traditional turbines

“NOW THE LAND AND SEA HAVE BEEN CONQUERED, SCIENTISTS AND ENGINEERS ARE LOOKING TO TACKLE THE SKIES”



The Makani kite flies at altitudes of up to 305 metres

ALTAEROS, MAKANI ENERGY, ISENTROPIC, CORBIS

“ENERGY STORAGE IS A CRUCIAL ASPECT OF A SECURE ENERGY FUTURE”

SUPERSIZE BATTERIES

The energy networks of the future will contain a higher proportion of energy from renewable sources than we have at present. But renewable energy resources are intermittent: a turbine can only generate power when the wind blows, a solar PV panel when the Sun shines. This intermittency means that energy storage is a crucial aspect of ensuring a secure energy future.

In university laboratories across the world, scientists are working on developing more efficient batteries with larger capacities and higher power densities. However, the battery is not the only energy storage solution. UK company Isentropic has developed an innovative Pumped Heat Energy Storage (PHES) system.

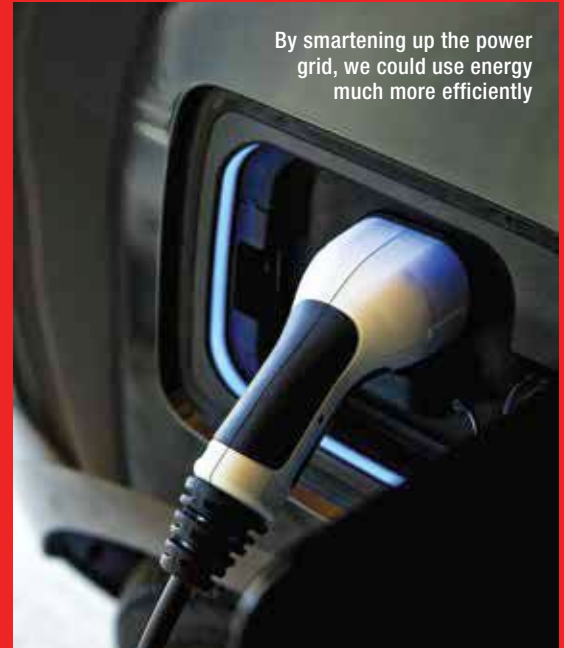
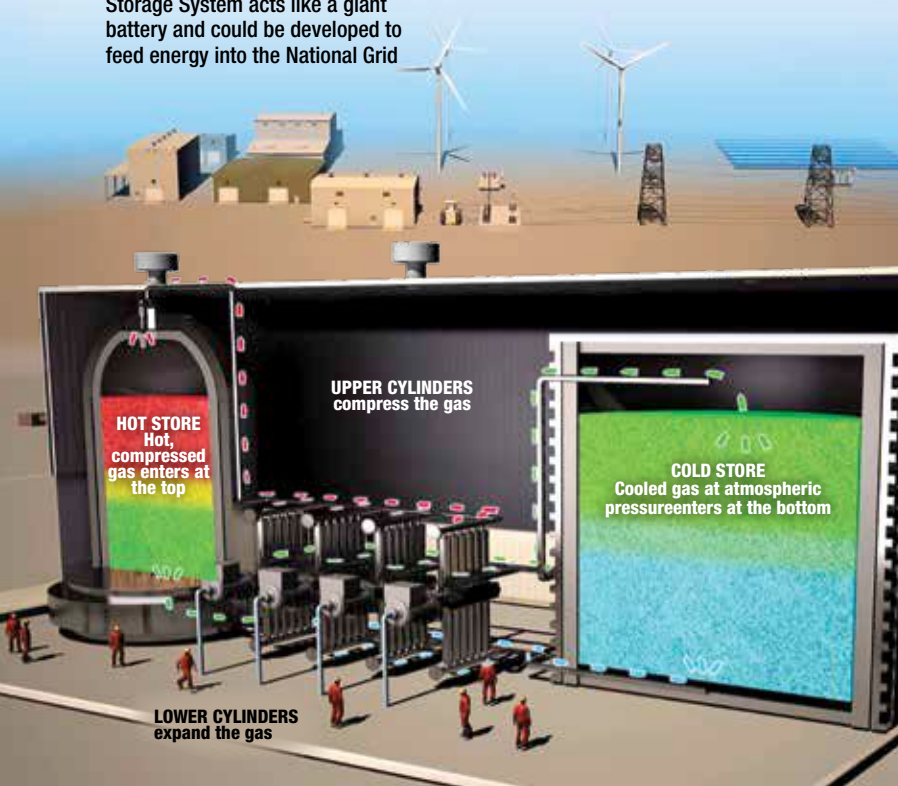
The PHES system operates as both an engine and a heat pump. Fundamentally, electrical energy

is stored as the temperature difference between hot and cold rocks. When the ‘battery’ needs to be charged, spare energy can be used to compress argon gas until it reaches 500°C. This hot gas is then used to heat up rocks, transferring the energy and storing it temporarily. The gas emerges from the rocks at atmospheric pressure (1 bar) and a temperature of -160°C.

To release the energy that is stored in the rock, the process is reversed. The argon gas flows in the opposite direction; this causes the gas to heat up so that it can be used to generate electricity through a mechanical engine.

The company is currently rolling out small (up to 1.5MW) and medium-scale (up to 50MW) PHES systems for businesses, but has plans to develop large scale (100MW+) systems for the electricity grid.

Isentropic's Pumped Heat Energy Storage System acts like a giant battery and could be developed to feed energy into the National Grid



By smartening up the power grid, we could use energy much more efficiently

MAKE THE GRID SMARTER

No single technology can hope to solve our energy needs. But some could make a big difference. One idea is called the ‘smart grid’. The grid is the network of cables, transformers and substations that deliver electricity to your home from a power station. The smart grid is all about building intelligence into the network to make the most efficient use of energy.

It could do a lot to mitigate the impact of climate change. A US report entitled Machine-To-Machine Technologies: Unlocking The Potential Of A \$1 Trillion Industry was published in 2013 by the dramatically titled US body Carbon War Room. The report estimated that smart grids could slash global greenhouse gas emissions by a fifth by 2020.

The smart grid would work by balancing the demand for energy. In future, we’ll have variety of renewable energy sources, as well as innovative energy storage systems such as PHES (see above).

Take electric vehicles, for instance, which would help to reduce carbon emissions. The vehicles will need to be charged, placing a burden on the electricity network. A smart grid would help to balance this extra pressure. Imagine returning home from work and plugging in your car. With a smart grid, the vehicle would not start charging instantly; instead, it would wait until the middle of the night when wind turbines are rotating but there is lower demand for energy.

To take this further, electric vehicles aggregated across a residential street or a company fleet could provide a useful energy storage resource. The batteries could be charged at periods of low demand, therefore making use of generation that would otherwise be surplus. At peak periods, they could return energy into the grid with the owner receiving a payment for electricity fed back in. Behind the scenes, computers will be managing demand.

MAKE CARBON VALUABLE

Is it possible to 'clean' emissions from traditional carbon-emitting forms of energy generation so that the waste carbon dioxide never actually reaches the atmosphere? Carbon Capture and Storage (CCS) aims to do just that. Despite the various renewable energy technologies in operation or development, some carbon-emitting forms of energy generation, such as the burning of fossil fuels, will undoubtedly remain part of our energy mix.

Carbon Capture and Storage (CCS) removes CO₂ at the point of generation – at power plants and factories, for

example. The industry has been around for a little while, with the first commercial CCS demonstration taking place in 2000. Nevertheless, the tech involved is becoming increasingly sophisticated.

A CCS system involves a host of technologies linked together in a chain: the capture of carbon dioxide at source, its transportation through a pipeline, and then its sequestration (safe storage). Efforts to improve the efficiency of capture, therefore eliminating a higher proportion of carbon dioxide from emissions, are ongoing.

Prof Peter Eisenberger, a researcher at Columbia University in the US, is taking things a stage further and hopes to build a machine that could suck carbon dioxide out of the atmosphere. His company, Global Thermostat, has installed a demonstrator of its air capture machine in Silicon Valley. Fans within a rectangular tower draw in air over surfaces called 'contractors'. Each contractor comprises 640 cubes containing a capture agent called amine sorbent that strips CO₂ from ambient air.

The main obstacle, as is so often the case, is money. CCS systems involve huge capital investment, so aren't necessarily that appealing to the owners of power stations. "New research and development will lead to better and lower cost solutions," says Dr Ward Goldthorpe, programme manager for CCS at The Crown Estate in the UK. "However, the real issue is the financial challenge. Currently, there is no market to dispose of carbon dioxide because society does not put a realistic price on the cost of carbon pollution."

Carbon Engineering is another company that thinks it is possible to 'scrub' CO₂ from the air. This is an artist's impression of its technology

CARBON ENGINEERING, NASA,


"THERE IS NO MARKET TO DISPOSE OF CO₂ BECAUSE SOCIETY DOES NOT PUT A PRICE ON CARBON'S COST POLLUTION"

FERTILISE THE OCEAN

Geoengineering describes ways to reduce global warming by removing carbon dioxide from the atmosphere or managing solar radiation. Taking the emphasis away from reducing greenhouse gas emissions has caused controversy, but some researchers say it's far too late to disregard the approach.

In 1988, the late oceanographer John Martin quipped, "Give me a half tanker of iron and I will give you another Ice Age". He said that a huge amount of iron dumped into the ocean would act as a fertiliser and cause plankton growth to increase. During photosynthesis, plankton draws CO₂ from the atmosphere – more plankton would mean more CO₂ absorbed, therefore slowing global warming. His idea caused enough of a storm to bring about a research effort.

"The scientific community hasn't done enough research yet to evaluate iron fertilisation as an effective carbon sequestration option," says Dr Kenneth Coale from Moss Landings Marine Laboratories, California State University. "Whether the carbon would be bound by the plankton for long periods of time remains one of the big open questions." Coale is adamant that it would need to be part of a wider strategy for CO₂ reduction and removal. "Reversing the trend would need a reduction in CO₂ emissions and a variety of mitigation measures, including geological sequestration. If effective, iron fertilisation could be part of a larger geoengineering portfolio," he concludes.



Plankton blooms, such as these in the Barents Sea, could lock up CO₂ from the atmosphere

**"GIVE ME A HALF TANKER OF
IRON AND I WILL GIVE YOU
ANOTHER ICE AGE"**



Wind-powered yachts could blast seawater into the sky

WHITEN THE CLOUDS

Another discipline OF geoengineering is solar radiation management. Unlike more outlandish proposals such as installing mirrors in space, scientists consider marine cloud brightening a more viable option. Researchers talk about two variants of Cloud Reflectivity Modification: cirrus stripping and marine cloud brightening. Thinning or 'stripping' high cirrus cloud would allow infrared radiation from the Earth to escape into space and result in a cooling effect. In turn, making low clouds more reflective could also reduce temperatures by taking advantage of the Twomey Effect, which is named after the Irish meteorologist Sean Twomey. The phenomenon describes how smaller water droplets lead to a 'whitening' of vapour in the atmosphere, which causes more sunlight to be reflected. Reducing the size of the droplets can be achieved with cloud seeding techniques, such as spraying seawater solutions from ships. Researchers at the Max Planck Institute for Meteorology in Hamburg, Germany are currently evaluating the approach. Dr Hauke Schmidt has been investigating the method's outlook as part of the international Geoengineering Model Intercomparison Project (GeoMIP). "One potential side effect is that we would have to commit to the technology – probably for centuries – otherwise climate change would quickly catch up," the geoengineering specialist says. Despite this, Schmidt thinks that the benefits might just outweigh the risks, and he encourages debate: "We must recognise that these proposals are on the table. The most sensible course of action is to try and fully understand the risks, side effects and positive outcomes such interventions are likely to have."

CONTROL THE RAIN

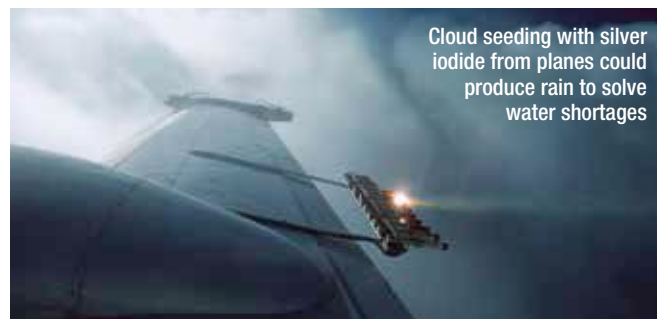
Drought affects ever larger areas of the planet. Most of the Arab world now falls under the classification of 'extreme water scarcity', as defined by the United Nations. North Africa and the Middle East are also facing rapid population growth – Yemen's population, for example, is expected to more than double by 2050, making large-scale water wars a real possibility.

A technology that may bring relief is cloud seeding. The use of silver iodide particles to act as tiny kernels for the formation of raindrops goes back a long way: it was pioneered in 1946 at General Electric by Bernard Vonnegut. His brother, Kurt Vonnegut, would later fictionalise the invention as Ice-Nine, a substance capable of instantly freezing all water on Earth.

Far from producing a freezing effect, silver iodide – alongside other substances such as salt or propane – is said to enhance rainfall. Cloud seeding from planes offers large savings over desalination, which costs around 50 to 60 US cents per cubic metre, according to Prof Zev Levin at the Energy, Environment and Water Research Centre of Cyprus. "If you can prove that it works, it's the cheapest solution, at three cents per cubic metre. It also avoids the need for expensive irrigation systems. The disadvantage is that it cannot be guaranteed to work when and where you want it to," the cloud and precipitation expert says.

Despite six decades of research, the jury is still out on cloud seeding. Science demands data, and comparison with unseeded clouds within the same weather system is notoriously difficult. Unperturbed, 37 countries are currently running over 150 weather modification programmes, according to the National Centre for Atmospheric Research in Colorado (NCAR). Scientists at NCAR are hopeful that their extensive statistical analysis will prove whether or not cloud seeding is feasible.

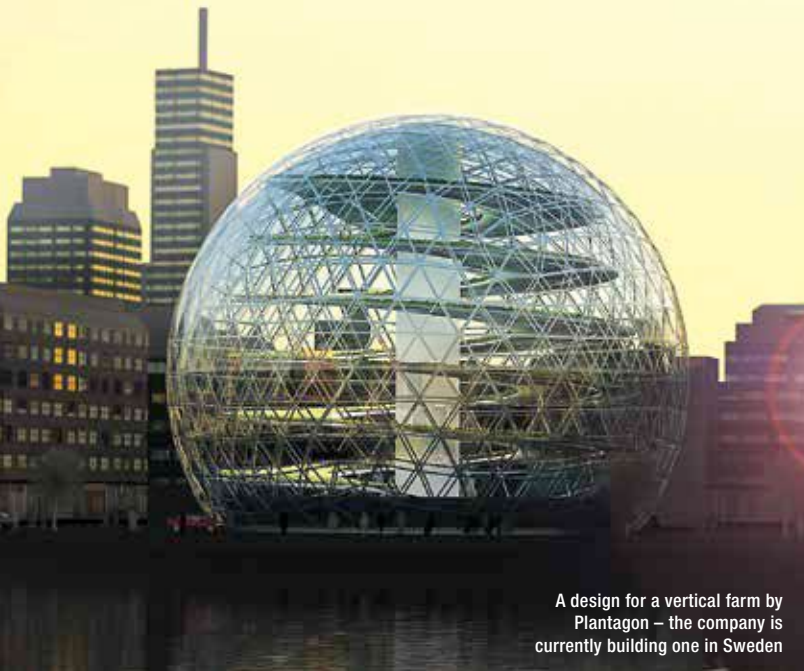
It may prevent wars. The Pacific Institute for Studies in Development, Environment and Security has recorded more than 100 conflict situations over water in the Middle East and North Africa (MENA) region. More than 250 people were killed in clashes over wells and pastoral lands in Somalia and Ethiopia between 2004 and 2006. Then again, countries might perceive cloud seeding as stealing 'their' water if they experience droughts. It may not be the panacea we're hoping for.



Cloud seeding with silver iodide from planes could produce rain to solve water shortages

"IF YOU CAN COOL THE SEA SURFACE, YOU WOULD CALM THE HURRICANES"

ENVIRONMENT | NATURE



A design for a vertical farm by Plantagon – the company is currently building one in Sweden

FARM VERTICALLY

At present, the World Health Organization estimates that half of the world's inhabitants live in cities. By the year 2050, this will increase to 80 per cent. By 2050, the world's population will have grown by three billion people and an additional space exceeding the size of Brazil will be required to grow enough food to feed everyone on the planet.

If over three-quarters of the world's food is to be consumed in urban areas, wouldn't it make sense to produce some of it in the cities themselves? It's an idea that prompted Columbia University scientist Prof Dickson Despommier to pioneer the idea of Vertical Farming. The microbiology and public health scientist thinks that in terms of area usage, his concept could outperform conventional farming by a factor of 10.

The key thought behind the technology is to grow food crops

across several storeys. There would be rotating access to sunlight or recently improved LED Grow Lights. Buildings would be put to double use, with space for office or living spaces as well as plant cultivation. "There is a duality to this. Yes, we need to produce food and conserve water. But we also need to start repairing damage to the ecosystems," Despommier explains. "With vertical farming, every indoor acre will allow 10 acres outdoors to be returned to growing what we need to soak up carbon, and that is hardwood forests."

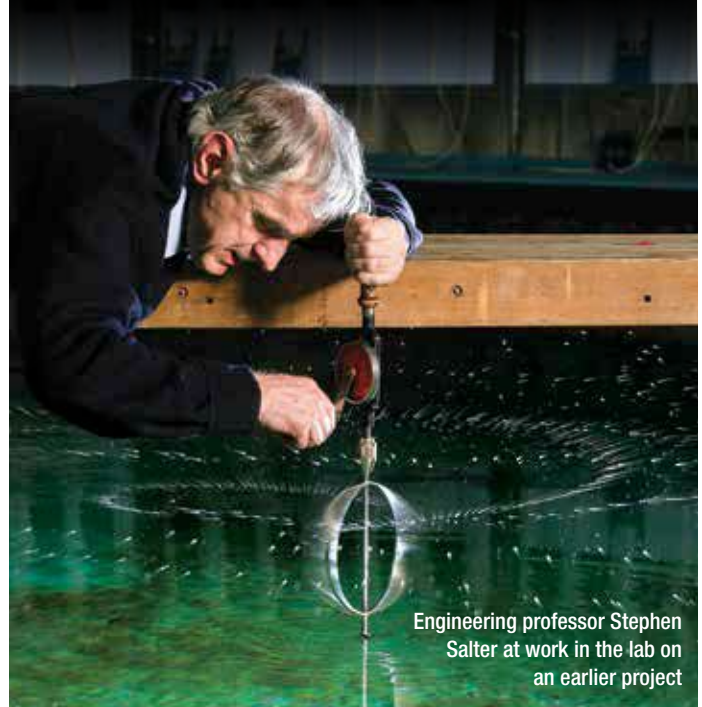
Many fellow developers agree – Despommier's idea is being implemented in different guises around the world, most notably at Pasona O2 in Tokyo, Japan. This pesticide-free urban farm is open to the public and occupies the ground and first floors, while a human resource company works across the other storeys.

HIT BACK AT HURRICANES

The last two centuries have seen hurricanes claim the lives of over 1.9 million people. They cause various problems, including destruction of infrastructure and the spread of disease. Damage wreaked by 2005's Hurricane Katrina cost \$108 billion to repair. It is likely that increasing global temperature may cause more devastating storms.

A typical Category 3 hurricane can produce energy equivalent to 10,000 nuclear bombs. Confronted with such force, can we really stop them? Billionaire philanthropist Bill Gates and British engineering professor Stephen Salter recently filed a patent with for a system of giant tubes extending 100m deep into the ocean. The system would mix water of different temperatures, therefore keeping the ocean's surface below 26.5°C – the critical level at which hurricanes form. Gates's effort is not his first. In 2009 he patented similar technology that relied on barges equipped with pumps and conduits. It was dismissed by some scientists who said the boats couldn't dredge up enough cold water within the time window offered in hurricane prediction.

This time, Gates and his team are more optimistic. Salter is confident he has fixed any problems, but thinks more funding is required. "If you can cool the sea surface, you would calm the hurricanes," Salter says. "I estimate you would need about 150-450 of these structures. They would drift around and send out radar signals so that nothing would collide with them."

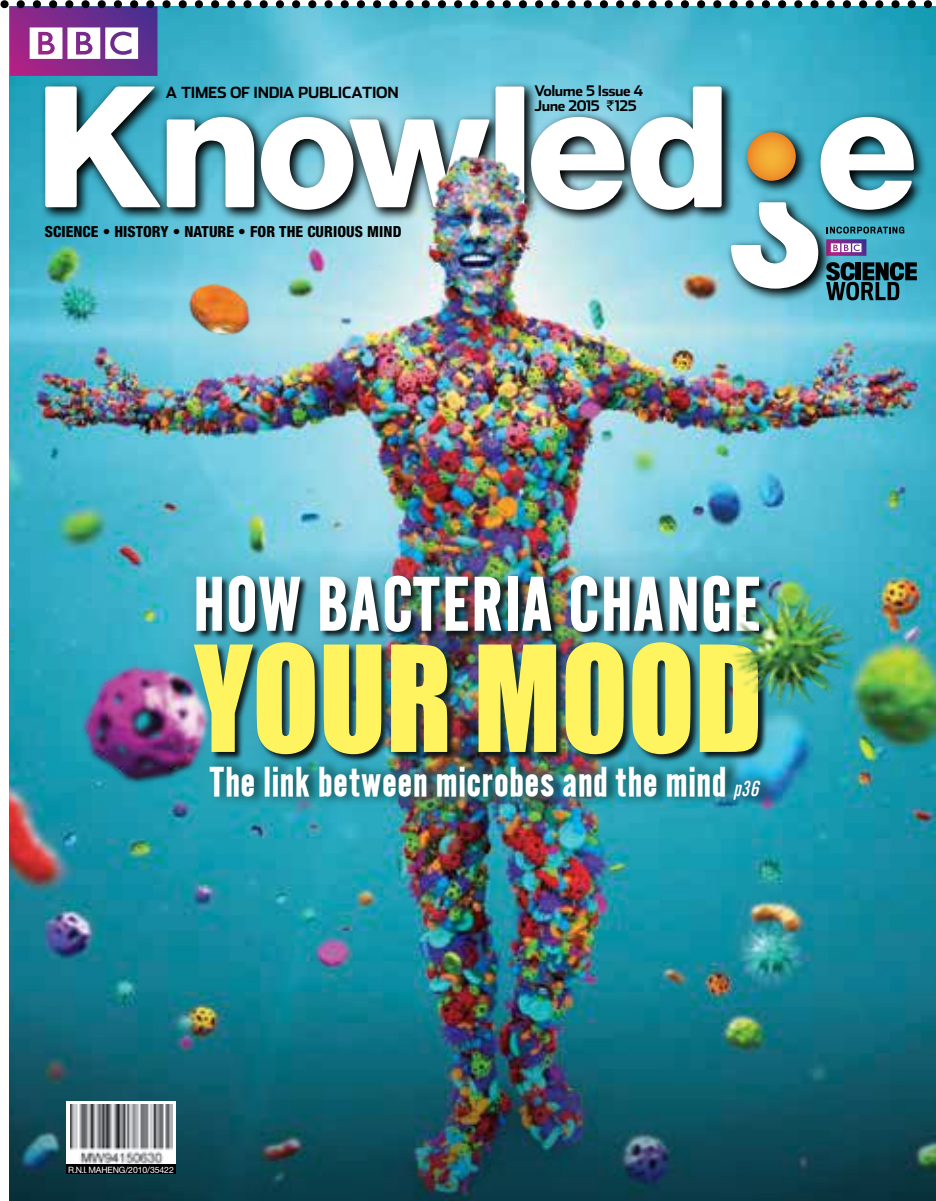


Engineering professor Stephen Salter at work in the lab on an earlier project

Alistair Welch and Max Mueller are science journalists with particular interests in technology and engineering.

MURDO MACLEOD, REX, MINDEN PICTURES/FLPA, JOHN MACNEILL

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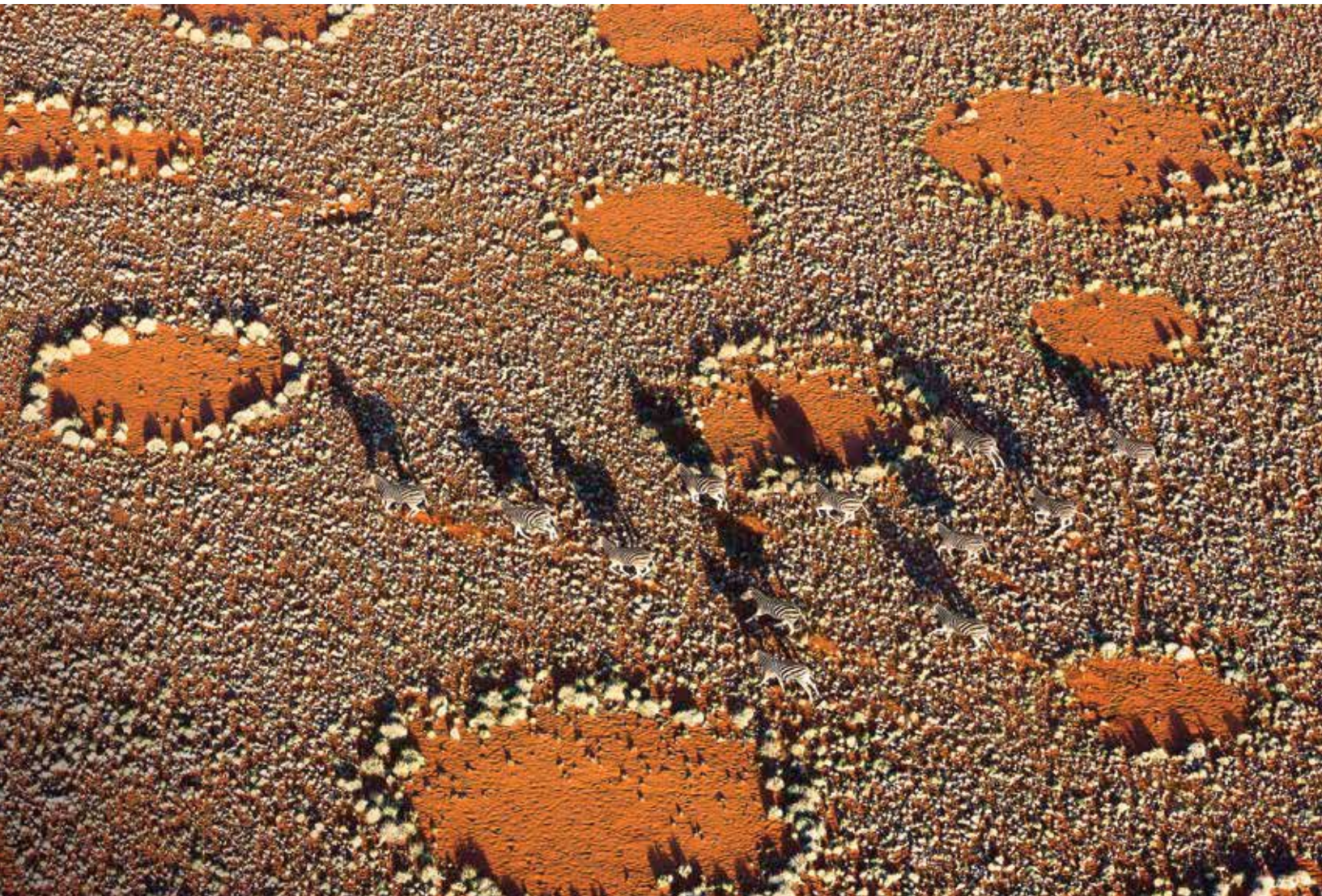
Life in the Namib Desert is harsh, and water is hard to come by. But evolution has equipped species that live in this challenging environment with a range of unique adaptations that are essential for survival.

Photos by Theo Allofs

SIP OF LIFE

Plains zebras survived as a small relict population when the NamibRand Nature Reserve was created in 1992, combining more than a dozen former livestock farms in a protected area exceeding 200,000ha. Water sources supplied by boreholes are spread more sparsely than before, but regularly maintained, supporting the zebras found widely through the reserve. Gemsbok (a species of oryx) also benefit – about 10,000 roam the NamibRand.





MYSTERY CIRCLES

Zebras gallop past mysterious grass-ringed patches known as 'fairy circles'. According to one story told by the Ovahimba tribe, these are the footprints of the gods; another claims that a dragon beneath the Earth's crust breathes fiery bubbles that burn the vegetation into rings. Despite decades of investigation, scientists still haven't established a definitive explanation for these curious formations.

FILLED INSIDE

The quiver tree is an aloe species with thick, succulent leaves growing from the end of tall branches. Lifting the leaves up to 6m above the heat radiating from the desert floor reduces moisture loss. The branches are covered in a fine white powder that reflects the sun's heat, and along with the trunk filled with a soft fibre that can store large quantities of water.

**IT'S A HERD LIFE**

The ostrich is well adapted to desert life. Its thick eyelashes protect its eyes from sandstorms, and its plumage insulates it from the worst of the heat. The bird doesn't sweat, and can live for prolonged periods while dehydrated, losing up to a quarter of its body weight in a day. In the morning they can be seen drinking at water holes or feeding on moisture-laden grass.







THE LONG WALK

The desert elephant is not a distinct species, but individuals tend to have longer legs and smaller bodies than other African elephants. In addition, flatter, more splayed feet make walking on sand easier – important when migrating tens or even hundreds of kilometres.

In the wet season, desert elephants prefer fresh green leaves, but during dry stretches they subsist on drought-tolerant species, eating just a small amount from one plant before moving on to the next.

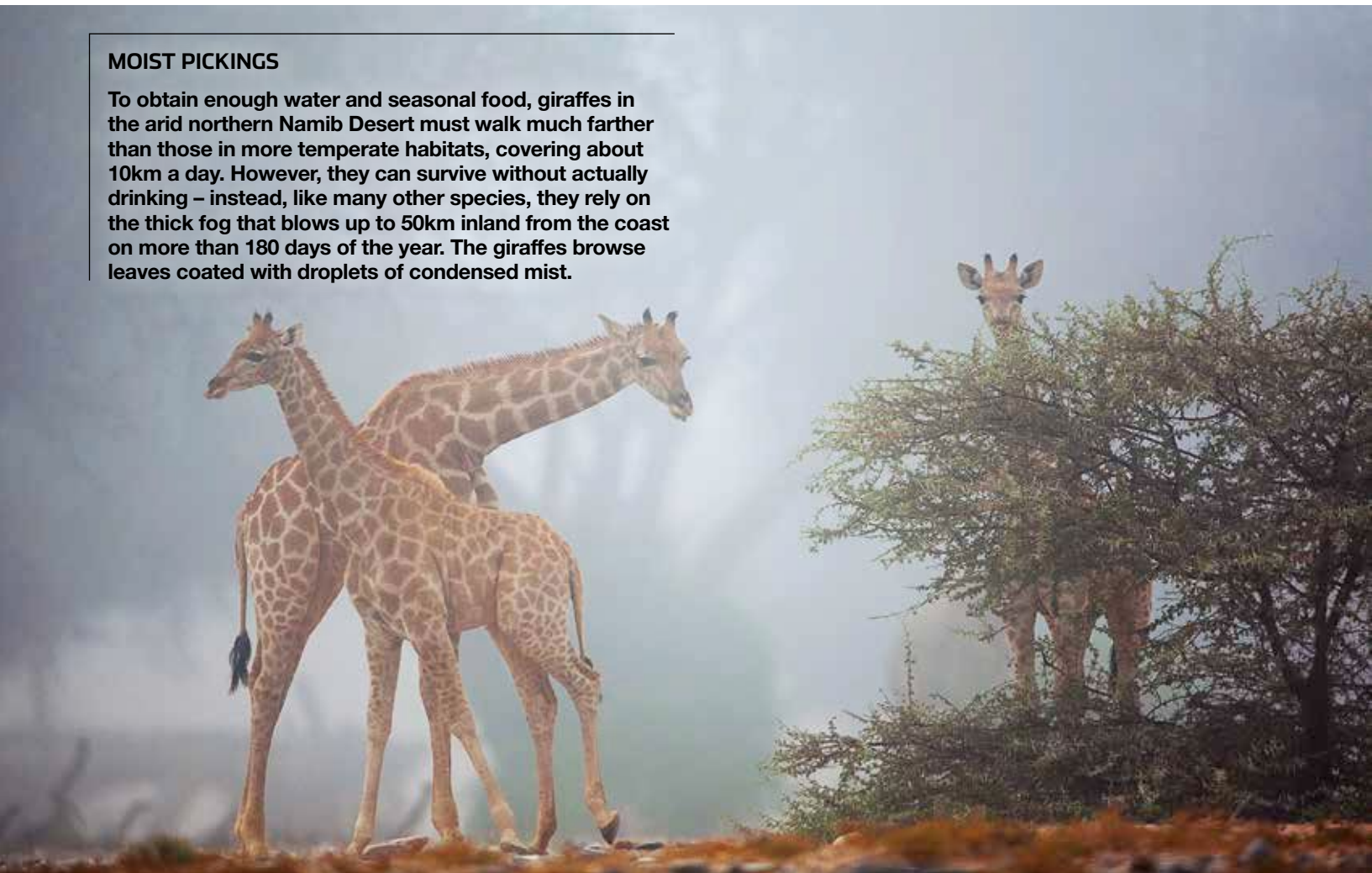
IN THE SWEATS

The gemsbok can allow its body temperature to reach 45°C before starting to sweat, and a large area of veined tissue in its nasal passages acts as a heat-control system. It grazes early in the morning when grasses are most moisture-laden, and also eats water-rich bulbs, roots and tubers.



MOIST PICKINGS

To obtain enough water and seasonal food, giraffes in the arid northern Namib Desert must walk much farther than those in more temperate habitats, covering about 10km a day. However, they can survive without actually drinking – instead, like many other species, they rely on the thick fog that blows up to 50km inland from the coast on more than 180 days of the year. The giraffes browse leaves coated with droplets of condensed mist.



FEATHER QUENCHERS

Namaqua sandgrouse gather at a water hole in the early morning, landing some distance away and waiting to check the coast is clear before wading in. When a female is guarding a brood, her mate will soak his breast before returning to mother and chicks, who drink from his feathers.



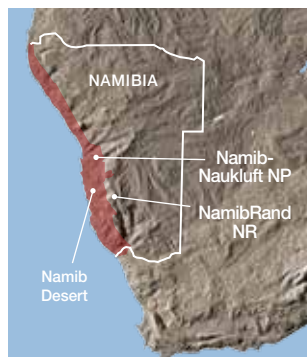
DO YOU SEE ME?

The Namib dwarf sanddagger is an ambush predator. The venomous snake buries itself in loose sand with just its eyes peeping above the surface – and, sometimes, the tip of its tail, which it may wave as bait to lure its prey closer. The sanddagger mostly eats small lizards such as the barking gecko and *Aporosaura* spp., the latter – having a relatively high water content – providing an important source of moisture.



THE LOCATION

Theo has been drawn back to Namibia many times since his first visit in 1995. A great fan of deserts, especially the Namib, five years ago he began a project on the desert elephants that roam the river beds in north-west Namibia. Later he extended his work to include the Namib Desert as a whole, and documented the survival strategies of many species in this arid habitat.



THE PHOTOGRAPHER

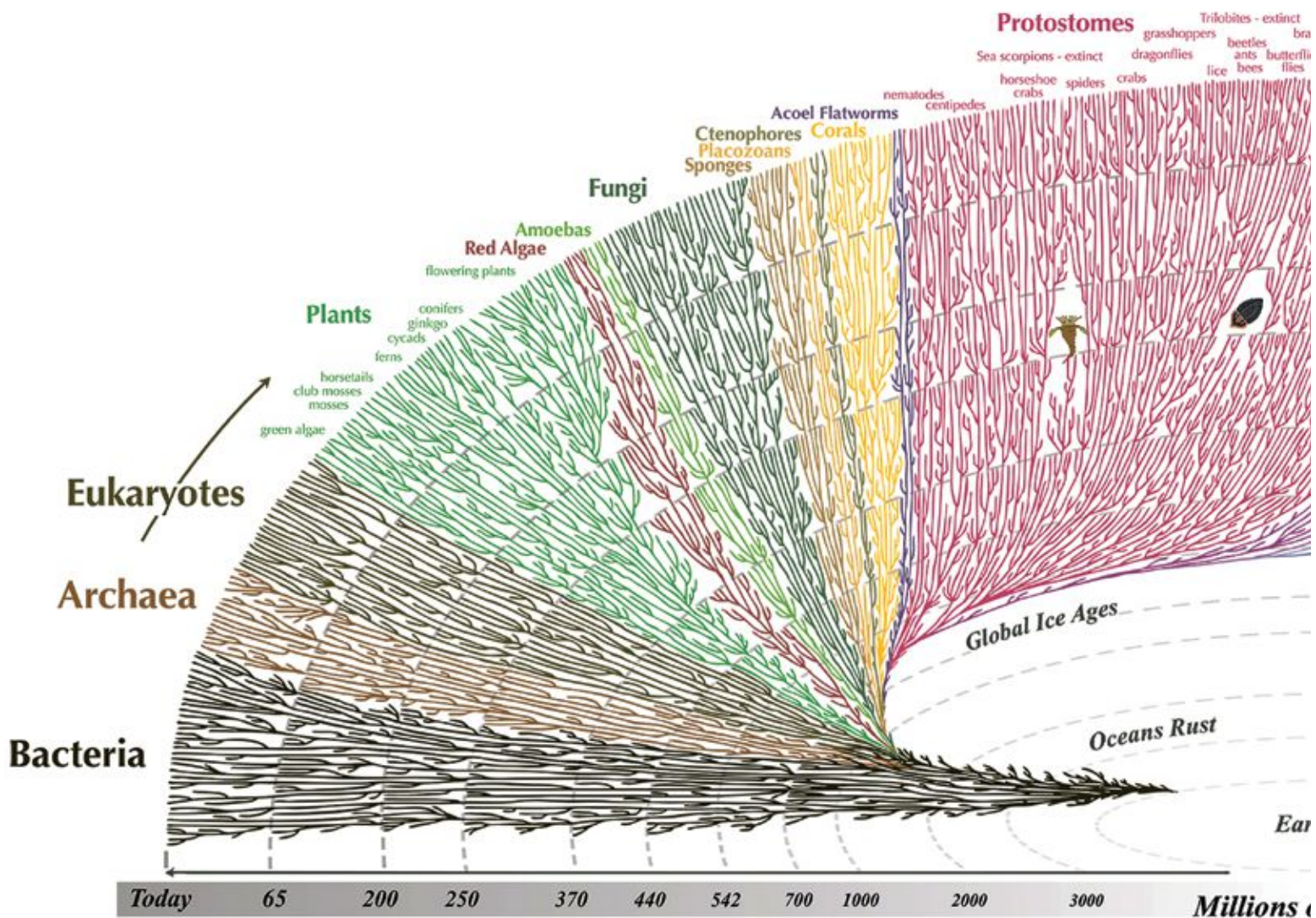


Theo Allofs has been a full-time nature photographer since 1995. His images have been published in most of the major natural-history magazines, and he is a founding member of the International League of Conservation Photographers (ILCP). www.theoallofs.com

THE GREAT TREE OF LIFE

Leonard Eisenberg and the Tree of Life web project in this rainbow-esque info graphic show how life evolved over 3.5 billion years

This Tree of Life is drawn from the human, mammalian point of view. That is why humankind, instead of some other organism, occupies a branch tip at the end of the tree, and why our vertebrate cousins (animals with a backbone) occupy a large part of the tree. This falsely suggests that humans are the ultimate goal of evolution. In fact, if that asteroid or comet that hit the earth 65 million years ago and helped wipe out the dinosaurs had instead missed the earth, there might not be a dominant, tool-using, space-



All the major and many of the minor living branches of life are shown on this dia

faring species on earth. Or if one evolved, it might be a dinosaur, not a mammal.

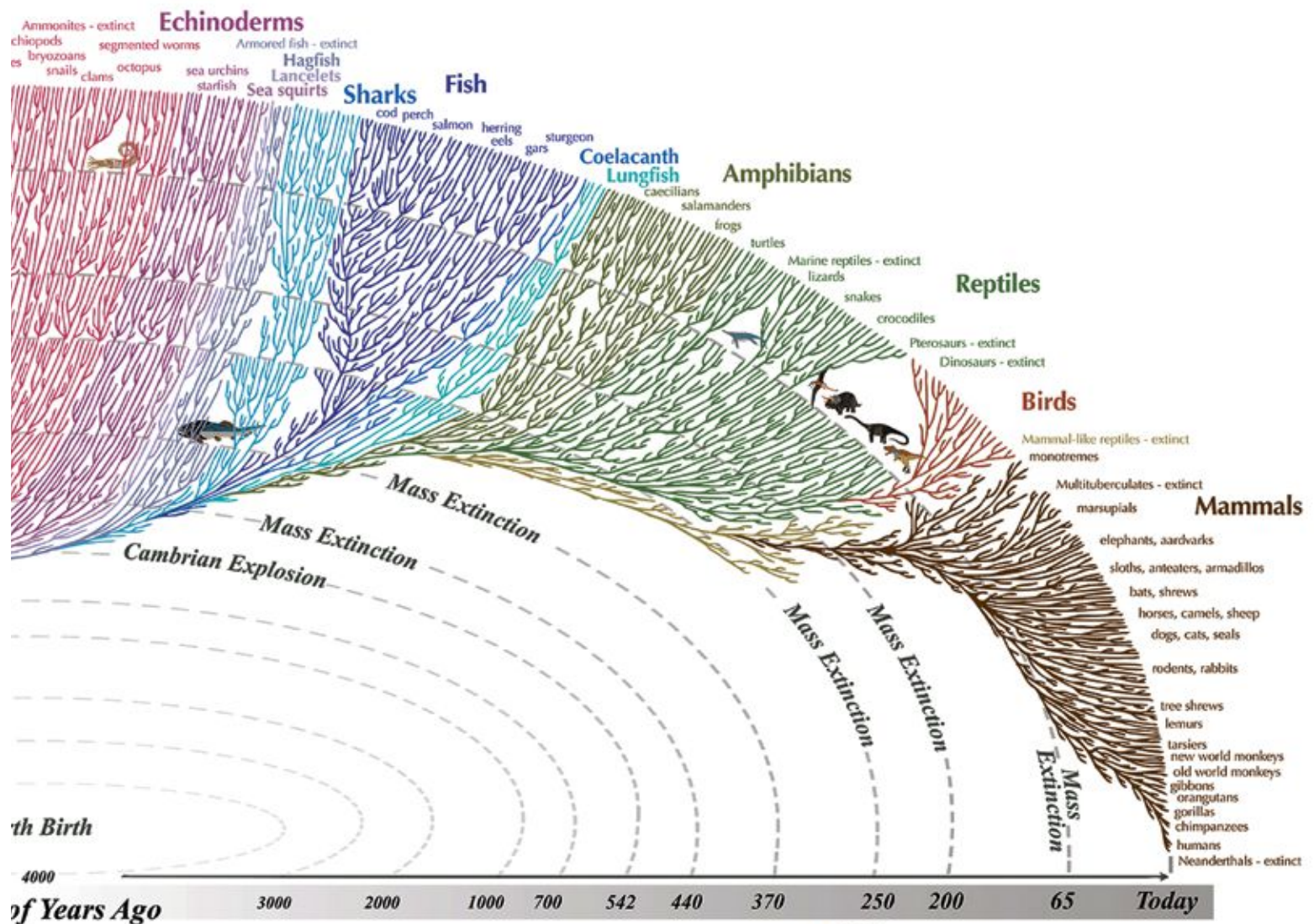
This diagram suggests life steadily increased in diversity through time, such that the greatest diversity appears to exist at the present time. This is not at all the case in life history, and only appears that way in this diagram because, for space reasons, only a few of the main branches of life that have gone extinct are shown. The evidence suggests that many

more branches have gone extinct than exist today. One estimate concludes that 99 per cent of species that have ever existed on earth are now extinct. If the diagram could be drawn to really reflect life history, the greatest diversity in major body plans would probably appear early in the Cambrian Period, around 530 million years ago. Only a few major body plans survived the Cambrian, but these few have evolved into the diversity we have today.

LEGEND:

This tree of life diagram illustrates common ancestry through the branching, family relationships between all life on Earth, and ties it to the geologic time scale. Time radiates outward from Earth Birth, at the center bottom of the diagram (more than 4500 million years ago), to the outer rim of the diagram, which represents time today. To find when a common ancestor between any two organisms lived, trace inward along their branches from the

rim to their intersection, then along the curved time lines to the time scale at the bottom of the diagram. For example, the common ancestor of elephants and frogs lived approximately 350 million years ago, making them 180 millionth cousins. The diagram shows graphically what evolutionary theory has confirmed, that humans are cousins not only to every living thing, but also to every thing that has ever lived. In other words, life on Earth is one, big extended family



Diagram, but only a few of those that have gone extinct are shown. Example: Dinosaurs - extinct

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evogeneo.com

Leonard Eisenberg is a geologist, who created Evogeneo to help people understand the history of Earth. Visit <http://evogeneo.com/> for more information

THE HISTORY ESSAY

THE LONG SHADOW OF ADOLF HITLER

The Nazi leader was not the only monster of the 20th Century – so why, 125 years after his birth, does he fascinate us more than any other despot?

Sir Ian Kershaw attempts to understand



Adolf Hitler mounts the steps at the Harvest Festival Rally at Bückeberg in 1934. Extraordinary demonstrations of power such as this were key in strengthening the growing personality cult surrounding the führer, says Ian Kershaw.

Adolf Hitler occupies a unique place in history. One hundred and twenty five years after his birth in the small Austrian town of Braunau am Inn, on 20 April 1889, the Nazi leader continues to cast a long shadow over the world. Our enduring fascination with his personality far outstrips our interest in any other dictator. But why? In a most obvious sense, the answer seems clear: Hitler was the chief author of the most devastating war, and the most terrible genocide, that the world has yet known. Certainly, that is reason enough to register his unparalleled impact on world history. It is also a good part of the reason why there have probably been more publications about Hitler than any other historical figure – apart, perhaps, from Jesus.

Hitler's primary responsibility for the colossal inhumanity of the Nazi regime warrants, of course, another question: what sort of individual could be capable of such unimaginable brutality? But we don't seem to be as concerned about answering this question when it comes to Stalin or Mao, both of whom were also responsible for the deaths of millions. Nor, in the case of Stalin or Mao, do we experience anything like the fascination that the minutiae of Hitler's character continue to exert.

This macabre fascination became more than evident to me from the flood of correspondence that followed the publication of the two volumes of my Hitler biography, in 1998 and 2000. Among the zanier missives I received, I was asked whether Hitler drank Tokaji wine at his wedding to Eva Braun, only hours before their joint suicide in 1945. Almost certainly he didn't – but what difference would it have made had he done so?

Another correspondent suggested that Hitler was descended from the British royal family, claiming that his ear measurements were (allegedly)

identical to those of Prince John, the son of George V and Queen Mary. The canard about Hitler visiting Liverpool in 1912 (he didn't) still surfaces repeatedly, despite all efforts to put it to rest. And the drama in the Berlin bunker at the end has woven its own spell, unmatched by the interest in the circumstances of the death of any other modern despot.

Stalin's paranoid refusal to believe that Hitler was dead (though the Soviets had been presented with a piece of jawbone in a cigar box, which could be authenticated as Hitler's) invented mystery where none existed and prompted persistent rumours that Hitler and Eva Braun had somehow been spirited away at the last to South America. I had numerous enquiries about the nature of Hitler's physical or mental illnesses, and various speculative diagnoses of these. The unstated implication was that if such an illness could be definitively established (it can't), that would be enough to explain world war and genocide; that, if Hitler could be shown to be mad, it would somehow account for the actions of the millions of sane individuals who were nonetheless anxious to put his ideas into practice.

If some of these examples are patently absurd, they serve to highlight the extremes of the

continued fascination with Hitler. In part this reflects an adherence to the 'great man' approach to history, bestowing on Hitler a sort of 'negative greatness', as some interpreters have done. Of course, some individuals – and Hitler was certainly one of them – have played major personal roles in shaping history, whatever the circumstances and impersonal determinants that conditioned those roles. However, the enduring preoccupation with Hitler goes far beyond a conventional interest in historical figures of great power and influence.

This stems, in some measure, from our continued sense of astonishment at a story without close parallel in modern history. Here was an individual who, for the first 30 years of his life, was a complete unknown, without education, qualifications, training, military leadership or family connections. Yet in the subsequent 25 years before his death, this figure was able to gain supreme power in one of the most sophisticated, cultured nations on earth. He went on to plunge Europe and the world into a war that cost more than 50 million lives, to instigate a genocide that aimed to wipe out 11 million Jews for no other reason than their ethnicity, and then to take his own life with the enemy almost literally at his door, his country ruined and occupied by enemy forces and the European continent utterly devastated.

We look for answers in an individual personality commensurate with the enormity of his impact, his hold over much of the German population, the power he wielded, the destructiveness that he produced – but we fail to find them. We see nothing in his odd personality, not to speak of his repulsive ideas, to explain such a devastatingly unique historical impact. Hitler remains an enigma.

Partly this is because he cultivated a sense of mystery; indeed, he would ►



This rare still of Hitler and his mistress (later, wife) Eva Braun is from a private home movie made by Braun's sister Gretl in the early 1940s.

not even let himself be photographed until 1923. His bizarre outward appearance carried its own appeal in the cultured salons of Munich's upper crust in the 1920s. He was acutely aware of the importance of public image long before that became a feature of political life. Though mocked by his adversaries, his trademark moustache was just that – a deliberately distinctive feature.

On his path to power, and especially after he became Germany's leader in 1933, propaganda outpourings embellished the enigmatic aura. His 'court' photographer, Heinrich Hoffmann, produced a series of bestselling books of pictures that popularised the sense of mystery. They aimed to show Hitler as a man of the people and, at the same time, the political philosopher of genius in lofty isolation, among the mountains that surrounded his Alpine retreat near the town of Berchtesgaden, Bavaria, as he pondered Germany's future and bore the entire burden of responsibility on his shoulders.

Hitler himself ensured that little material could be produced by his enemies to challenge or undermine the constructed imagery of heroic genius. The Gestapo seized and destroyed whatever documents they could find relating to his early life; indeed, much of what we know about his time in Linz and Vienna before the First World War is dependent on loaded 'memoirs' by a number of individuals who knew him reasonably well.

Only fragmentary evidence remains to elucidate a vital period of his development: a handful of his letters surviving from the First World War, a few official military records, and some recollections of contemporary comrades seen through the distorting mirror of his later fame. Hardly any later personal letters or memorabilia of Hitler himself have survived, because he ordered them all to be destroyed

“Hitler isolated his private sphere from his public life – and in an era before prying 24/7 television news and social networks, he was able to sustain this separation to the end”

just before his death. He even kept his mistress a secret. Before the demise of the Third Reich, Eva Braun was a name known to hardly anyone in Germany outside Hitler's inner circle. This demonstrates his success in isolating his private sphere from his public life – and in an era before prying 24/7 television news and social networks, he was able to sustain this separation to the end.

Hitler poses with his propaganda minister Joseph Goebbels, the latter's wife, Magda, and three of their children

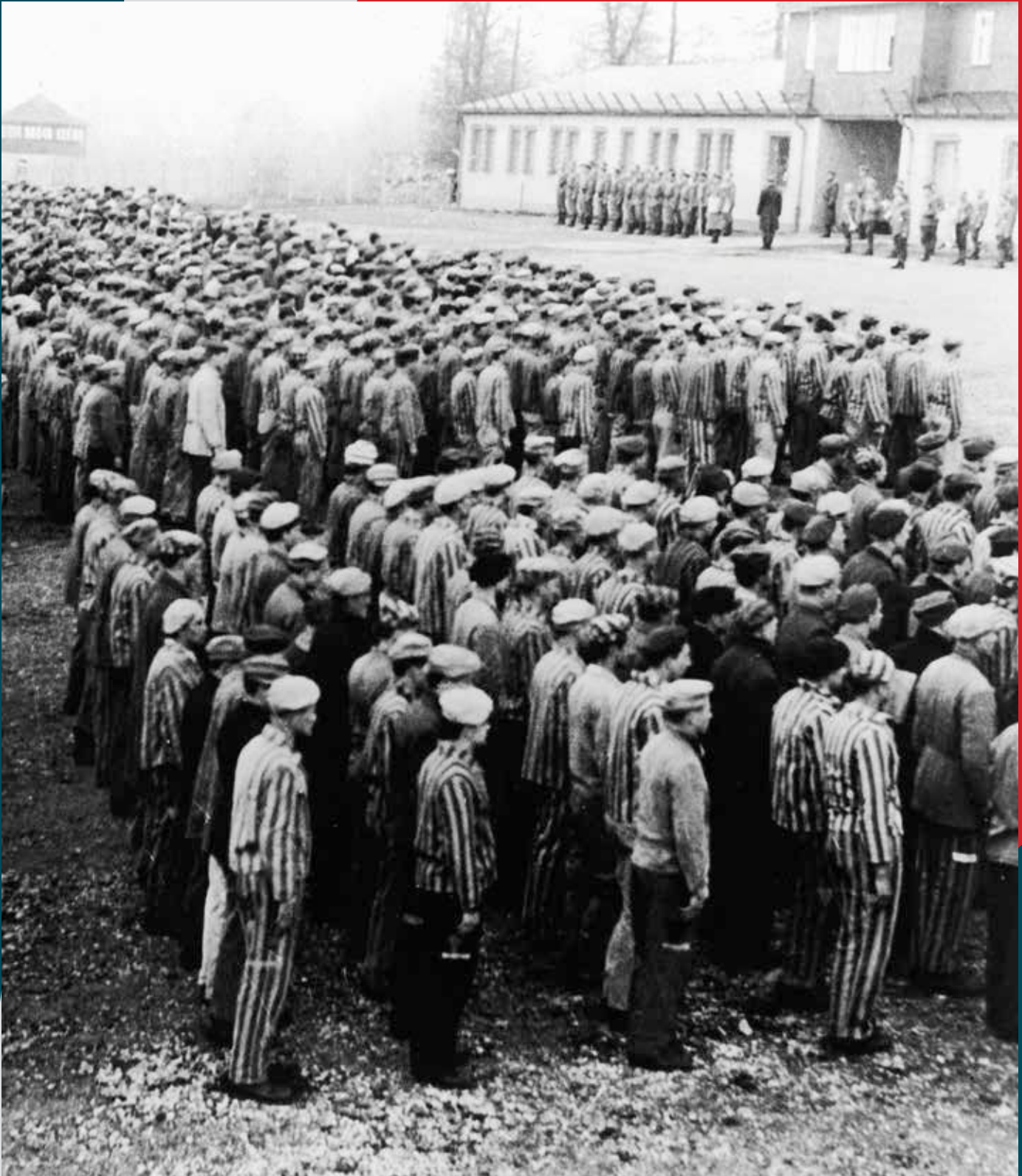


Hitler purposely built up a wall of aloofness that very few were allowed to penetrate. He had hardly any intimates or genuine personal friends. Any urge for relaxation was tempered by the need to uphold his image. He did sometimes show a human side to his character: for example, playing with the Goebbels children; in his passionate love of Wagner's music, proclaimed during his visits to the Wagner clan at Bayreuth; or in biting mimicry when among his usual circle at his retreat on the Obersalzberg, near Berchtesgaden. But he was an excellent actor who could play many parts without allowing the mask of his leader's position ever to drop completely.

In his private sphere, Hitler was surrounded by fully fledged adepts of the personality cult of the leader: his regular entourage included his ubiquitous organiser and factotum, Martin Bormann; his adjutants and manservants; his secretaries; his close party cronies and their wives; one or two favourites, such as his propaganda minister, Joseph Goebbels, and his wife, Magda; and the architect Albert Speer. They spent time with him at close quarters but, though Goebbels especially was capable of critical insight, swallowed any criticism in favour of adulation. Hitler's 'achievements' were magnified.

Above all, his 'vision' seemed incomparable. Even at Hitler's Obersalzberg home, the Berghof, there was no real discussion in his presence. When Hitler spoke, everyone listened. No one sought to contradict him or enter into genuine argument. Whether met with rapt fascination or with bored passivity (his audience having often heard similar expositions many times before), the 'genius' of the führer was never questioned.

Hitler was not without ability or knowledge. He was, of course, a masterly demagogue – the basis



Polish prisoners at Buchenwald concentration camp near Weimar, c1943. The world continues to ask itself what sort of individual could be capable of the brutality displayed by Hitler. Yet it doesn't seem so concerned with asking the same question of Stalin or Mao.





Hitler makes a speech in 1934. He was among the first leaders to utilise radio and film for disseminating propaganda.

of his early dominance within the Nazi Party. More than any other contemporary German politician, he spoke in a language that gave voice to the anger and prejudice of his audience. It was effective because the message was both simple and radical – and because it was not the contrived product of a team of advisers and backroom spin-doctors but, rather, reflected his own burning hatreds. He wrote his own speeches and paid great attention to their delivery. Far from mere rants, they were finely attuned to the mood of the audience as he expertly played on the feelings his rhetoric awakened.

He also read a lot, if superficially and essentially to bolster his own prejudice. His excellent memory enabled him to recall information on

many subjects. This impressed not only those around him and others who were already susceptible to his message, but also experienced ministers and foreign diplomats who were surprised at his detailed grasp of a complex brief, and military leaders whom he could outwit by his awareness of technical specifications of weapons or operational dispositions.

He knew a great deal about aspects of classical music, art and architecture – if within the confines of his limited, inflexible taste – and enough to pontificate about history, religion and culture. This was the knowledge of the opinionated autodidact – but many highly respected politicians have known less, about less.

As his path to power and then his dominance of European politics

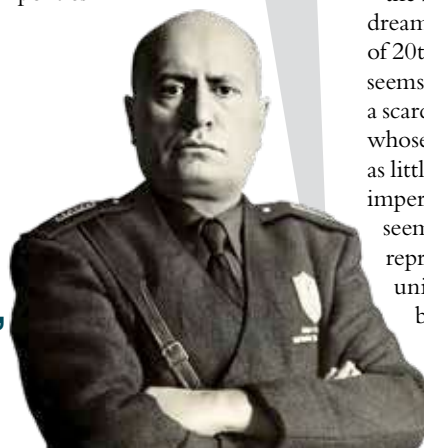
during the 1930s showed, he was also politically astute, especially adept at dividing his opponents and going for the jugular where he detected weakness. It is impossible, however, to separate his talents from the aura of power that was constructed around him – an aura that certainly owed something to his own manufacture but was largely the creation of others.

This aura was elaborated through the regime's extraordinary demonstrations of power: the spectacular Nuremberg Rallies; the pervasive death cult manifested in the annual march through the streets of Munich to commemorate the fallen 'martyrs' of the failed putsch of 1923; or the monumental building plans intended to match those left behind by Pharaonic Egypt or classical Greece and Rome. He and Mussolini were also the first state leaders to maximise the use of radio and film for propaganda purposes.

Hitler was the clear focal point of these displays of power. Those of Fascist Italy, of Stalin's USSR, of Mao's China, of present-day North Korea and of other modern despotisms seem somehow less remarkable. It may be no coincidence that militaria fetishists appear to be far more captivated by German uniforms and SS paraphernalia than by those of Stalin's or any other army.

Why is this? Could it be that there is a certain awe, if in a purely negative sense, at the nature of Hitler's vision – the scale of his megalomaniac dreams and ambitions? In the parade of 20th-century despots, Mussolini seems, however misleadingly, not just a scarcely credible buffoon but one whose territorial ambitions betray him as little more than an old-fashioned imperialist in modern garb. Franco seems a dull dictator – highly repressive, but in personal terms an uninteresting, narrow-minded bigot. Stalin looks like a modern variant of Russian tyranny

Benito Mussolini's dictatorship has cast a far smaller shadow than Hitler's



"Hitler was a masterly demagogue. More than any other contemporary German politician, he spoke in a language that gave voice to the anger and prejudice of his audience"



A man examines the bones of some of the hundreds of thousands of victims of Pol Pot's regime in Cambodia. What happened here, while "unimaginable in scale", seems to pose "no great mystery", says Ian Kershaw. Yet Hitler's crimes appear scarcely explicable.

down the ages, his mass murder (largely of his own citizens) mind-boggling yet somehow unsurprising. Even more remote to our mentality is Mao's China, where the horrors – as in Cambodia under Pol Pot or, more recently, in Rwanda – seem unimaginable in scale but to pose no great mystery.

Hitler, on the other hand, triumphed in a liberal democracy in a country not far away and not enormously different from our own. How he was able, in a short time, to transform that country into one engaged on a mission of racial conquest and genocide still seems scarcely explicable. And the vision of such horrific megalomania – the obliteration of major cities such as Leningrad or Moscow, the 'ethnic cleansing' of the entire continent and, of course, the death sentence

pronounced on millions of Jews – still leaves us spellbound at the sense of the total, unconstrained power that Hitler embodied.

The unprecedented steepness of the descent into untold inhumanity is what underpins the continuing search for a better understanding of the man at its head. Hitler is the face of evil of the 20th Century. Yet so successfully did he efface his own biographical remnants that even a most crucial question remains unanswered: we cannot be sure precisely when, why and how he became the pathological anti-semitic without whom the Holocaust – the central emblem of his political evil – is unlikely to have happened.

So should we be marking the 125th anniversary of his birth? I must confess that I do not greatly warm to the fad for historical anniversaries, and I am

still less a fan of the 'great man' approach to historical explanation. To my mind, the eccentricities of Hitler's personality are less crucial than the reasons why the people of Germany were prepared to implement what they saw as Hitler's will.

Still, Hitler's imprint on history was profound. So the anniversary is worth noting, not for any quirky obsessiveness with the minutiae of his character but because it reminds us of the most catastrophic collapse of humanitarian values – values that had lain at the heart of western political and moral thinking since the Enlightenment. And if this collapse happened once in European history, could it do so again? 📍

Professor Sir Ian Kershaw is a historian formerly based at the University of Sheffield, and is the best-known modern biographer of Adolf Hitler.

The Intel International Science and Engineering Fair (ISEF) is scheduled to be held in Pittsburgh, Pennsylvania from 10-15 May. This student science competition sees 1,700 finalists from over 78 countries worldwide, who vie for \$4 million in awards, scholarships and honours. The icing on the cake for winners includes the chance to be present at the Noble Awards ceremony and even have a minor planet named after them.

Representing India, 20 students from across the country will be heading to ISEF to showcase 12 ideas that will shake up the fields of science, technology, engineering and mathematics. These lucky 20 have been chosen after winning the Initiative for Research and Innovation in Science (IRIS) competition. Let's hope that these young minds join the ranks of previous winners who've brought pride to the Indian contingent.



For further information:

www.irisnationalfair.org

IRISNationalFair

Announcing the winners of #IfICouldTeleport Contest

Ever wished if you could teleport? If yes, then where to? BBC Knowledge posed this very thoughtful question to its readers and our fans responded with gusto. Under the hashtag #IfICouldTeleport, the contest had the participants sharing their destinations choices - ranging from Hogwarts to the Andromeda Galaxy and some even back to the early 90s. Seen here are some of the entries from where Jumjum_02, varun_khera and Maibam Ricky Devi were declared as the three winners.



SMARTWATCH SHOWDOWN

Smartwatches are getting smarter all the time. Paul Lamkin straps on four of the latest models...

Smartwatches have come a long way since our last wearable tech test. The first wave of devices suffered from short battery lives, grainy displays and clunky interfaces, and didn't stay on our wrists for long. But now, with the help of Google's Android Wear platform, the world's biggest tech companies have given their smartwatches a new lease of life. We asked Paul Lamkin of wareable.com to put four to the test.



MOTO 360 MOTOROLA

₹ 17,999

WEIGHT: 49G
DISPLAY: 1.56-INCH
WIRELESS: BLUETOOTH
BATTERY LIFE: ONE DAY
PROCESSOR: 720MHZ

The Moto 360 created the smartwatch revolution's first real 'wow' moment when it was shown at Google's I/O conference in 2014. Not only was it one of the first devices to run the all-new Android Wear OS, it also came with a round watch face – its Korean rivals from Samsung and LG both combined dull rectangular faces with lacklustre designs. It's a fine looking watch, if a tad on the chunky side, but the display is a disappointment, and not just because it's a standard LCD. The 360's biggest crime is the dead area at the bottom of the face that makes a mockery of the 'first circular smartwatch' claim.

This display is off most of the time, and automatically turns on to reveal the

clock face as you look at the screen – a feature designed to save the battery. But getting your horological fix requires an exaggerated, theatrical movement to illuminate the screen, and we often found ourselves having to tap the screen just to check the time. Fitness is a big theme of the Moto 360. It keeps track of your step goals and heart rate; Heart Activity sets you a target of 30 minutes' moderate activity a day and tracks your progress.

Google Keep enables you to make notes using your voice. Voice recognition is generally good, but in a moderately noisy environment the system soon falls apart. What's more, if you're replying to messages by speaking there's no opportunity to verify the content.



GEAR S SAMSUNG

₹ 24,900

WEIGHT: 67G
DISPLAY: 2.0-INCH
WIRELESS: 3G, WI-FI, BLUETOOTH
BATTERY LIFE: NOT SPECIFIED
PROCESSOR: 1GHZ

Samsung's plan of attack with its products – be they TVs, tablets, smartphones or kettles – is to throw a load of products at the wall and see what sticks. The smartwatch is no exception. The Korean company has launched no fewer than six Gear-branded wearables in the last 12 months, the most intriguing of which is the flagship Samsung Gear S.

Marketed as a 'standalone' smartwatch – one that can work without being tethered to a smartphone – the Gear S offers 3G, Wi-Fi and GPS connectivity on the go. You can make and receive calls on it and even send text messages using the tiny keyboard. In reality, you'll do neither, and the fact you'll need a Samsung Galaxy phone to activate it in the first place seems

lost on its makers.

Once you're past the initial fiddly set-up process you're presented with a massive smartwatch running Samsung's own Tizen OS – a platform with over 1,000 apps, we're reliably informed, though good luck finding one you'd consider essential.

The real beauty of the Gear S is that two-inch, 480 x 360, curved Super AMOLED display. In the screen stakes, Samsung's smartwatch has no competition. Its pixels per inch count of 300 is pretty much unrivalled and if you're looking for a wearable that's going to be a head-turner, look no further. However, it's almost impossible to recommend the Gear S: it feels at best like a work in progress.



SMARTWATCH 3

SONY

₹ 13,999

WEIGHT: 45G
DISPLAY: 1.6-INCH
WIRELESS: BLUETOOTH, NFC
BATTERY LIFE: TWO DAYS
PROCESSOR: 1.2GHZ

Sony's SmartWatch 3 may not be the best looking smartwatch on the block but it may well be the most useful. And that's because it includes GPS connectivity – essential for accurate run-tracking – and a battery that's bigger than any of its Android Wear rivals. All Android Wear watches allow you to use apps like RunKeeper and MyTracks to record running routes and distances covered, but right now it's only the Sony offering that lets you do this without having to lug your smartphone around with you. We compared it against dedicated running watches from the likes of Garmin and Adidas and found the accuracy to be pretty much on the money, so it's ideal for anyone considering both a smartwatch and a

specialised running watch.

As well as running smarts, the SmartWatch 3 also gives you all the usual Android Wear functionality such as notifications, navigation and music controls, and that 420mAh battery should mean that you'll only need to charge it every other day (unless you're training for a marathon, that is). The design may be a little on the basic side – Sony misses the target in its attempt to look sporty, but it's a comfortable fit and is pretty durable.

The SmartWatch 3 also has NFC (near-field communication) and Wi-Fi connectivity, and there's a good chance that future Android Wear updates will add functions that make use of these – Google Wallet, for instance.



PEBBLE

PEBBLE TECHNOLOGY

₹ 10,2000s

WEIGHT: 38G
DISPLAY: 1.26-INCH, EPAPER
WIRELESS: BLUETOOTH
BATTERY LIFE: 5-7 DAYS
PROCESSOR: ARM, 80MHZ

The Pebble is pretty ancient in wearable tech terms, having first burst onto the scene with a crowdfunding campaign back in 2012. But it's only recently that it went on sale in the UK, so we thought it only right we include the device that, literally, kickstarted the smartwatch movement.

Despite still being a big seller, the Pebble now looks pretty dated compared to its wrist-seeking rivals. And while its e-paper display will go a long way to boosting battery life – you can realistically expect five to six days of 'normal' usage – it's housed in a

clumsy-looking plastic chassis that looks anything but cutting edge, and has fallen behind in an industry determined to align itself with traditional watch design and luxury fashion brands.

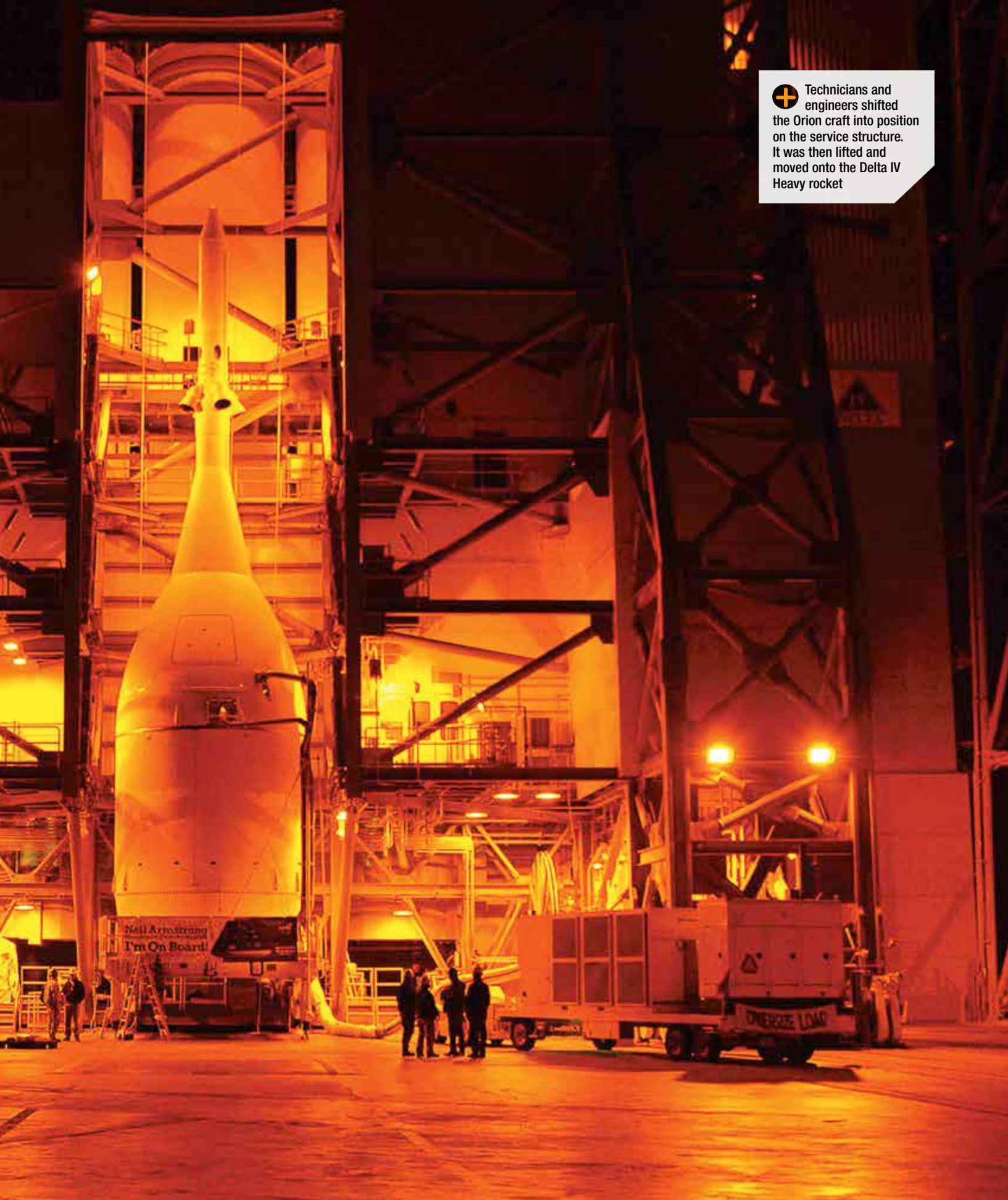
The huge interest in the Pebble however, means that there are now thousands of apps and extensions designed to make this smartwatch more than the simple notification assistant it was built to be. You can only store eight apps on the Pebble at any one time, but thanks to the Pebble Locker, syncing apps from your smartphone is a painless affair.

Paul Lamkin is editor-in-chief of Wareable.com, a website dedicated to wearable technology.

A NEW DAWN FOR NASA

Orion embarked on its maiden voyage in December 2014, putting NASA back in the manned space race. Dr Neil Ashton straps himself in for the ride

 Technicians and engineers shifted the Orion craft into position on the service structure. It was then lifted and moved onto the Delta IV Heavy rocket



Apollo 17 splashed into the Pacific Ocean on 19 December 1972 after completing the final mission of the Apollo space programme. It marked the end of an 11-year effort to take humans to the Moon. NASA had first achieved this feat just three years earlier with Apollo 11.

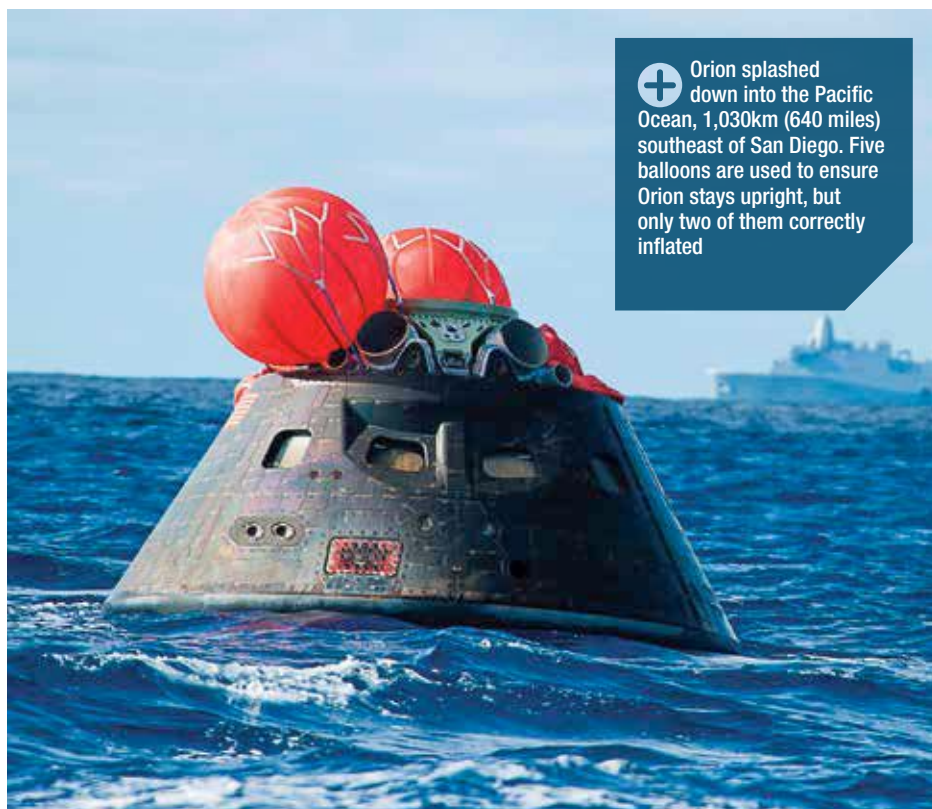
NASA's latest craft, Orion, finally gives the space agency the ability to take humans beyond the Earth once again. On 5 December 2014 it completed its first test flight, dubbed Exploration Flight Test 1. For this flight, Orion was launched by the world's most powerful rocket, the Delta IV Heavy, taking it 5,794km (3,600 miles) above the Earth, more than 10 times further away than the International Space Station. After nearly four hours of spaceflight, it started its descent back to Earth. On the way down it reached speeds of over 32,187km/h (20,000mph) and then attained temperatures in excess of 2,000°C during its re-entry.

The first mission was designed to test the top risks that Orion would face on a mission into deep space. These included the ability of the heat shield to protect the spacecraft on return, the pyrotechnic-induced separations at various stages of the mission and the guidance, navigation and propulsion systems. While the data from the maiden flight is still being analysed, a first look at the information suggests it was a huge success for NASA. "We're ecstatic; there aren't adjectives that describe how well overall the spacecraft did," says Mark Kirasich, Orion's deputy programme manager at NASA. "Our exploration programme at NASA is all about re-establishing human exploration beyond low-Earth orbit."


The origins of Orion date back to 2004. A new crew module, service module and ►




⊕ Orion undergoing final assembly at the Kennedy Space Center. Technicians ensured that no foreign objects contaminated the spacecraft while it was being put together



⊕ Orion splashed down into the Pacific Ocean, 1,030km (640 miles) southeast of San Diego. Five balloons are used to ensure Orion stays upright, but only two of them correctly inflated



 The Orion craft
blasted into space on
5 December 2014 aboard
the Delta IV Heavy, which
is the most world's most
powerful rocket

**“BY 2021 THE
FIRST MANNED
MISSION WILL
BE LAUNCHED”**

“EVENTUAL MANNED MISSION TO MARS IN THE 2030S” LAUNCHED

rocket were planned, together with a lunar lander. But a change in the US administration ultimately led to the programme being cancelled, and NASA went back to the drawing board.

Out of this rethinking came two objectives. First, to commercialise the re-supply of crew and cargo to the International Space Station. This has since led to two private companies, SpaceX and Boeing, being awarded contracts to take over the responsibility of ferrying astronauts and cargo to the space station. This capability allows NASA and its lead contractor, Lockheed Martin, to concentrate on the development of deep space human exploration missions.

Blast off

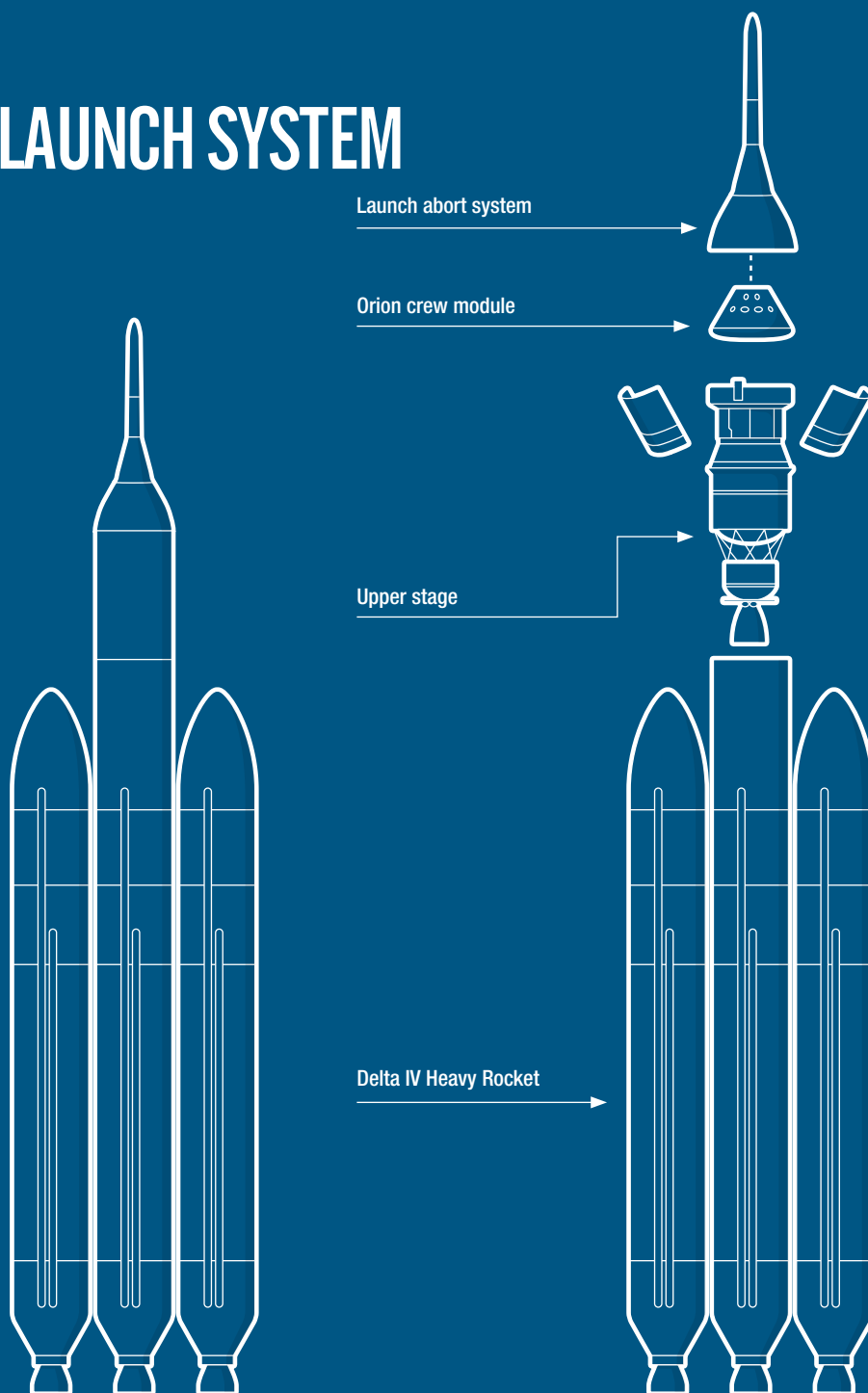
This second objective resulted in the Orion spacecraft, whose design came largely from the previously cancelled Constellation programme. In addition to Orion, a new and powerful rocket called the Space Launch System (SLS) has been developed. The SLS will have the capacity to eventually take Orion to Mars.

You could easily be forgiven for thinking that the Orion spacecraft is, in fact, Apollo in disguise. Larry Price is Orion's deputy programme manager at Lockheed Martin. As he explains, NASA's extensive storehouse of knowledge came in handy when designing Orion. “The shape

BLAST OFF!

The Delta IV Heavy is the world's most powerful rocket. It launched the Orion crew module and launch abort system into space

LAUNCH SYSTEM



ORION'S FIRST FLIGHT

Hours: minutes: seconds after launch

1

0:00:00

On 5 December 2014, Orion launched on the Delta IV Heavy rocket from Kennedy Space Center

2

0:06:10

The service module and the launch abort system separated – this was a critical part of the mission

3

1:57:11

The upper stage of the system reignited after completing one orbit around the Earth

4

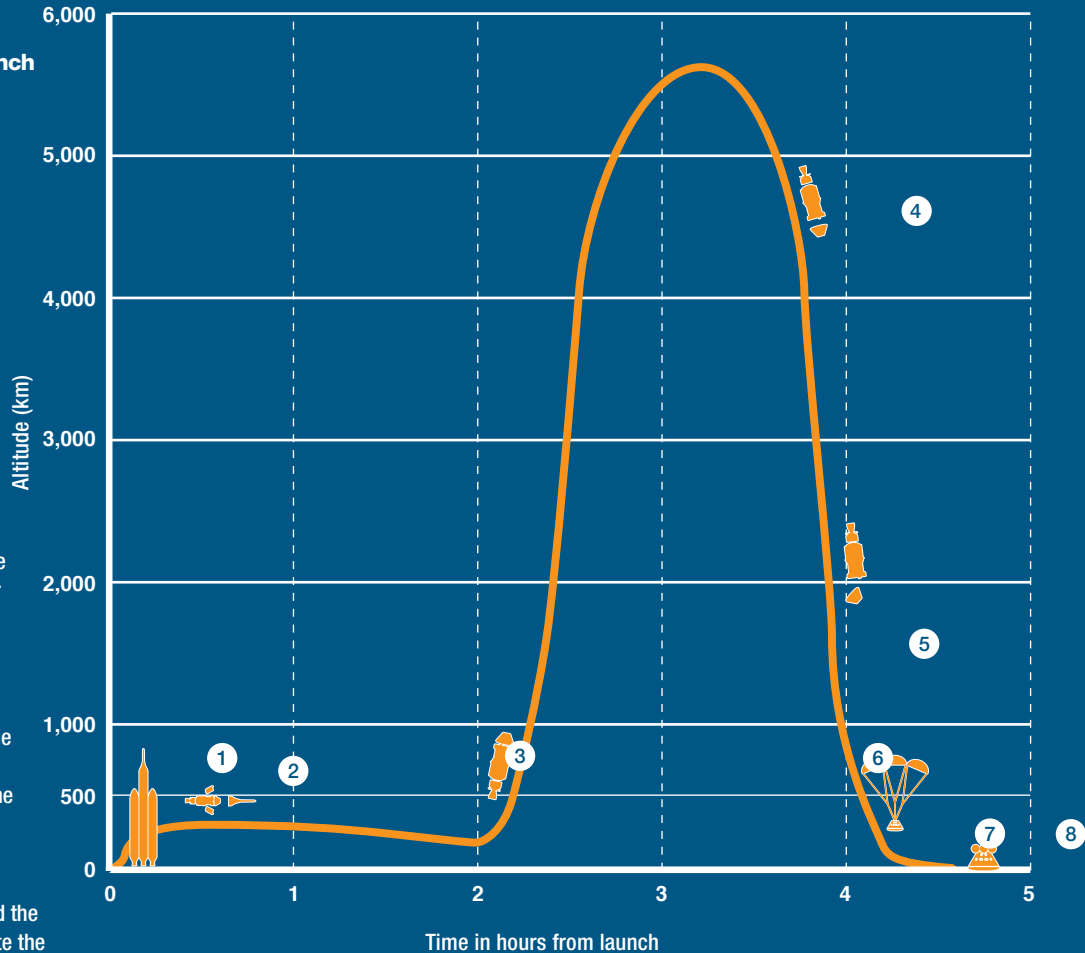
3:23:41

The Orion crew module separated from the service module and the upper stage

5

3:57:00

The crew module fired the control jets to orientate the craft correctly for re-entry into the atmosphere



6

4:13:41

The Orion crew module made contact with the Earth's atmosphere at an altitude of 805km

7

4:20:22

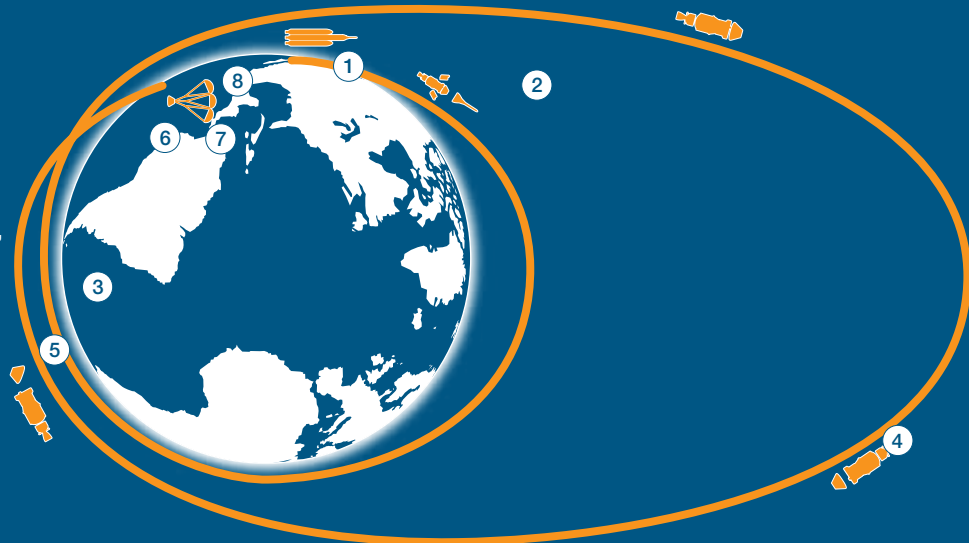
Forward bay cover separated, starting the parachute deployment sequence

8

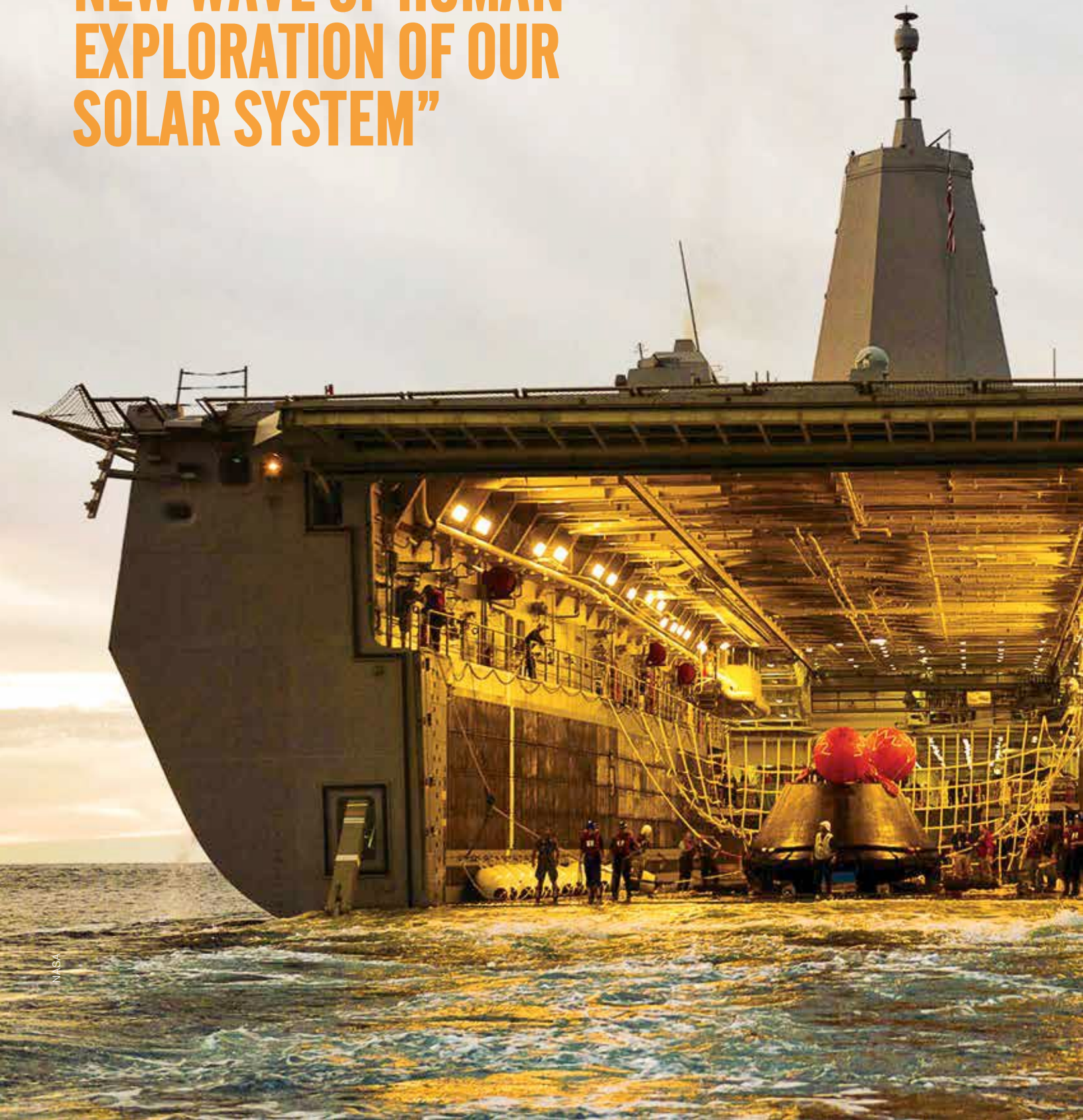
4:24:46


Orion landed safely in the Pacific Ocean and was recovered by NASA and the US Navy

HOW ORION ORBITED EARTH



**“THIS IS THE START OF A
NEW WAVE OF HUMAN
EXPLORATION OF OUR
SOLAR SYSTEM”**





Orion seen in the well deck of the USS Anchorage. US Navy divers recovered the spacecraft after Orion's first exploration flight test

reduces the time and cost to develop a system based upon the existing data we've got from the Apollo programmes," he says.

This mission marks the first step towards an eventual manned mission to Mars in the 2030s. Next year, further test flights with updated hardware will take place. And in 2018, Exploration Mission 1 will launch an unmanned Orion aboard the new Space Launch System, sending it into orbit around the Moon. This will be used to test the guidance and navigation systems as well as the radiation protection equipment. By 2021 the first manned mission will be launched, called Exploration Mission 2. This mission is currently proposed to send astronauts to a captured asteroid, so they can collect samples and bring them home.

Before any humans fly onboard Orion, one hugely important part of the system will be thoroughly tested. The Launch Abort System (LAS) fits around the crew module, with a spike housing three rocket motors. If the main rocket should fail, the LAS's rockets would fire within milliseconds to pull the crew module out of harm's way before deploying parachutes for a safe landing.

Mars mission

Many challenges lie ahead before the final goal of sending astronauts to Mars, however. At present Orion is designed to only take four astronauts for missions lasting up to 21 days. This is because there isn't enough space to store water and supplies for longer missions. An eventual mission to Mars would rely on various other components, such as a habitat module.

But the need for humans to undertake such missions is something that NASA is convinced is necessary. Exploration Flight Test 1 was just the start of a long journey for NASA, but it is one that could ultimately mark the start of a new wave of human space exploration of our Solar System and will inspire a new generation of scientists and engineers. 📺

Dr Neil Ashton works at The University of Manchester's School of Mechanical, Aerospace and Civil Engineering.

HOW DO WE KNOW?

THE NATURE OF GRAVITY



BY BRIAN CLEGG

What goes up must come down, as the old saying goes. But why that's the case is a mystery that took some of humanity's greatest minds centuries to figure out – and some aspects of gravity remain a puzzle

Here are four fundamental forces that operate in the Universe: the strong nuclear force, the weak nuclear force, the electromagnetic force and gravity. Gravity is the most obvious of these – yet it has proved a difficult puzzle to crack.

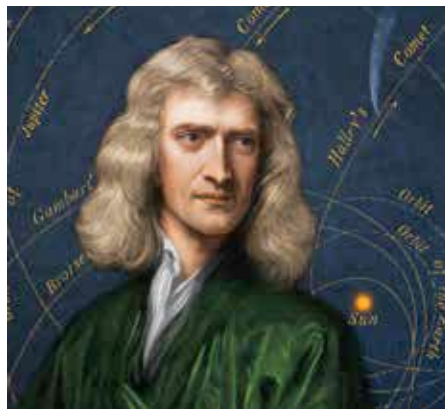
To the ancient Greeks, gravity reflected the nature of the elements. Aristotle described how earth and water had gravity, and there was a tendency of motion towards the centre of the Universe (the Earth). Air and fire, he said, had levity, which encouraged them to move away from the centre. But these tendencies were only present in the imperfect, sub-lunar realm. In the Greek world view, everything from the Moon upwards depended on the fifth element, quintessence, which allowed the heavenly bodies to rotate undisturbed.

To understand Aristotle's viewpoint, we need to forget all we learned about physics at school. Gravity was not a force – it simply described the nature of earth and water. It was their natural tendency to seek out the centre of the Universe, just as it is a dog's natural tendency to fight cats.

Although gravity would be refined over the years, there were few serious challenges to Aristotle's domination of the physical sciences for 2,000 years.

Down to earth

The great 7th Century Indian mathematician Brahmagupta briefly flirted



Newton was the first to realise that gravity is a force that all objects, however small, exert on each other

with the idea that gravity might work in a similar way to a magnet, as did the Islamic scholar al-Biruni 300 years later, but this wasn't enough to shake Aristotle's dominance. The first cracks appeared with the transformation of the Solar System by Copernicus and Galileo. If they were correct, and the Earth travelled around the Sun – making that the new centre of the Universe – then Aristotle's model of gravity fell apart. Based on reasoning rather than observation and experiment, Aristotle's ideas required the Earth to be the centre of the Universe. If it were the Sun instead, all heavy matter should fly off into space.

What's more, Aristotle's model of gravity made heavy objects fall faster than light ones. With more material in them, the heavy objects should feel a stronger urge and therefore move faster. Aristotle stated this as fact – yet Galileo demolished the idea. He asked what would happen if you tied together two objects of different weight. The heavier weight, according to Aristotle, would want to fall faster and would speed up the lighter one – but the ►

< **IN A NUTSHELL**

The ancient Greeks thought that earth and water were drawn towards the centre of the Universe, then believed to be the Earth. But thanks to Galileo, Newton and Einstein, our knowledge of this fundamental force has come a long way since the 4th Century BC.



light weight should slow down the heavier one, leaving them falling at an intermediate speed. Yet the combined object was heavier than either, so the whole should fall faster. It didn't make sense.

Although Galileo almost certainly didn't, as legend has it, drop weights off the Leaning Tower of Pisa to discover that they arrived at the ground at the same time, he did experiment with pendulums that had bobs made of cork and lead, one "more than 100 times heavier" than the other, and showed that they swung (and hence

fell under gravity) at the same rate. He also repeatedly rolled balls down sloping channels to measure the effects of gravity. And Galileo explicitly described a 'force of gravitation' that pulled weights towards the Earth.

But it was Isaac Newton who brought gravity fully under the auspices of science and mathematics. It's not clear whether he was truly inspired by seeing an apple fall (it certainly didn't fall on his head), though he did make this claim. In a long chat with the antiquarian William Stukeley in April 1726,

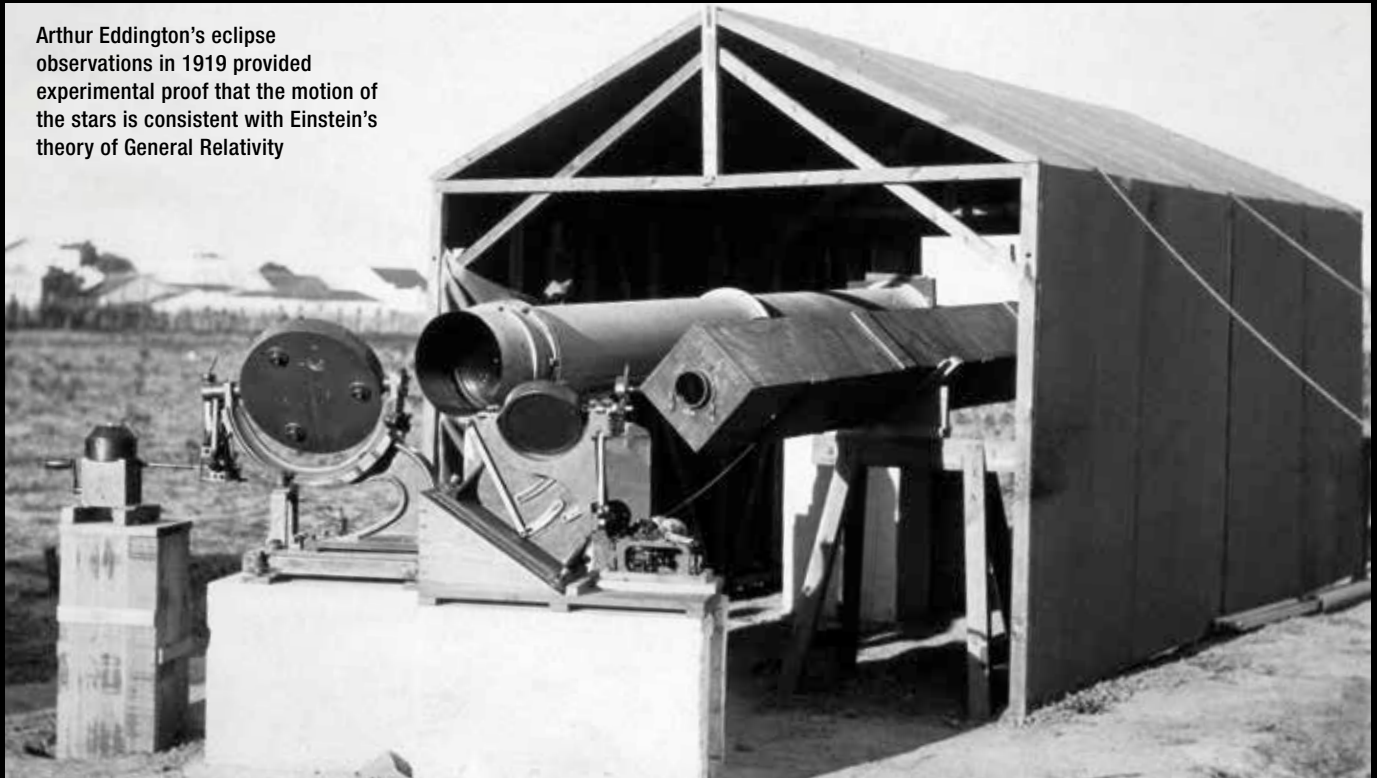
the elderly Newton described how the fall of an apple made him think, "Why should the apple always descend perpendicularly to the ground?"

In Stukeley's account, Newton says that the apple is pulled by a 'drawing power' to the Earth, and that this force must be proportional to its quantity. The apple draws the Earth, and the Earth draws the apple. But more than this, Newton made the leap of proposing 'universal gravitation'. He broke Aristotle's lunar barrier and applied the same force throughout the

THE KEY EXPERIMENT

PUBLISHED IN 1915, EINSTEIN'S THEORY OF GENERAL RELATIVITY CAUSED A STIR, BUT IT WASN'T UNTIL FOUR YEARS LATER THAT ITS PRACTICAL EFFECTS WERE OBSERVED FOR THE FIRST TIME

Arthur Eddington's eclipse observations in 1919 provided experimental proof that the motion of the stars is consistent with Einstein's theory of General Relativity



GENERAL RELATIVITY LARGELY agrees with the predictions of Newton's theories, but the most obvious difference is in the way gravity bends the path of light. When light from a star passes close to the Sun, its path should, according to General Relativity, bend inwards, shifting the star's apparent position. This could only be seen when the Sun's light is blotted out.

In 1919, Arthur Eddington led an expedition to Principe Island off West

Africa to make measurements during the total eclipse on 29 May. That morning brought thick cloud and rain until around noon. With the eclipse due at two, hopes were low. Eddington commented, "We had to carry out our photographs in faith. I did not see the eclipse, being too busy changing plates, except for one glance to make sure that it had begun, and another halfway through to see how much cloud there was. We took 16 photographs." But image after

image showed no clear stars; only two plates proved usable. Yet with supporting information from an expedition to Sobral in Brazil, Eddington confirmed General Relativity's predictions and boosted Einstein to celebrity status.

Ironically, later tests suggest Eddington could not have had accurate enough measurements to confirm the theory. But since then, huge amounts of data have proved Einstein's predictions rock solid.

Universe, realising that gravity was responsible for keeping the planets in their orbits, where otherwise they would fly off in a straight line.

All this and more Newton put into his masterpiece, *Philosophiae Naturalis Principia Mathematica*, usually known as the *Principia*. The book itself, originally written in Latin, is not easy to read and relies far more on geometry than we would expect today, but here we get the key understanding that the force of gravity is dependent on the masses of the objects involved divided by the square of the distance between them. This and his laws of motion were enough for Newton to describe the way that planets and moons move and the way that things fall when they drop. It was, without doubt, a triumph.

However, Newton did leave one aspect hanging – which is how this strange force acting at a distance could work. He writes in *Principia* ‘hypothesis non fingo’, translated as ‘I frame no hypothesis’. This was a sly comment: in using the word ‘frame’, as in framing someone, Newton was suggesting that his competitors were making things up. Still, this gap in explanation left Newton open to attack, particularly for his use of the word ‘attraction’. Today we are familiar with ‘attraction’ being applied to gravity, but at the time it was only used in the romantic sense. He seemed, to 17th Century ears, to be saying that the Earth orbited the Sun due to some kind of planetary crush.

Newton had not worked in isolation. His great rival Robert Hooke, for instance, had suggested that gravity was an ‘inverse square law’ that reduced with the square of the distance, but Hooke had been unable to manage the maths to support his idea. It took Newton to assemble the magnificent whole.

Gravity explained

Despite his protestations, Newton did have some thoughts on how gravity might work. He suspected, as many did, that there was an invisible material in space that could transmit the force. Such mechanical models for gravity became more sophisticated with time. The most popular was that of Nicolas Fatio de Duillier and George-Louis Le Sage, both Swiss scientists who independently developed the idea that space was full of tiny invisible particles that constantly bombarded bodies from all directions. When something got in the way, like the Earth, it sheltered other ►

CAST OF CHARACTERS

Five great thinkers whose work was crucial in shaping our understanding of gravity



Aristotle

(384-322 BC)

The definitive ancient Greek philosopher, born in Stagirus, Aristotle set the agenda for science for over 1,800 years. This is a pity, as his theories – based on reasoning rather than observation – were almost universally misleading. Gravity as Aristotle saw it was a tendency for heavy things to prefer the centre of the Universe.

Galileo Galilei

(1564-1642)

This natural philosopher from Pisa believed in the importance of experiment, and as a result dismissed Aristotle's ideas on gravity. Though famous for being tried for promoting the Copernican model of the Solar System, Galileo's greatest contribution was his methodical exploration of mechanics and motion, including the influence of gravity.



Isaac Newton

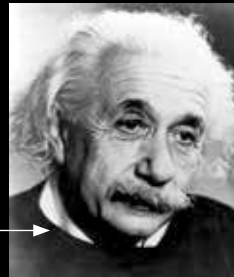
(1643-1727)

The greatest English physicist. Most of his work on light, motion, gravity and calculus was done in Cambridge, though much was achieved when he was confined to his home in Lincolnshire due to the plague. He was later an MP, Master of the Mint and President of the Royal Society – but physics remains his most significant legacy.

Albert Einstein

(1879-1955)

Einstein was born in Ulm, Germany, though he was a Swiss citizen from his teens. He produced three papers in 1905, while working in the patent office, that would show atoms were real, lay the foundation of quantum theory and establish Special Relativity. His theory of General Relativity from 1915 is still the standard theory of gravitation.



Arthur Eddington

(1882-1944)

Born in Kendal in the Lake District, Eddington worked as an astronomer and astrophysicist in Cambridge. When asked if it were true that only three people in the world understood the theory of General Relativity, Eddington is said to have replied, ‘Who is the third?’

TIMELINE

Six important steps on the road to our modern understanding of how gravity works



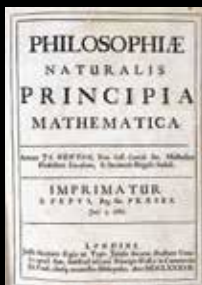
Aristotle adds *The Physics* to his works, a collection of eight books that describe his theories on the behaviour of natural and moving things, including gravity and the opposing concept of 'levity'.

350
BC

1638

Galileo's last book, *Discorsi E Dimostrazioni Matematiche, Intorno À Due Nuove Scienze* [*Discourses And Mathematical Demonstrations Relating To Two New Sciences*] is published, including his ideas on gravitation.

Newton's *Philosophiae Naturalis Principia Mathematica* is published, a three-volume work in which he outlines his theory of gravity as well as his famous laws of motion.



1687

1907

Sitting in his office in the Swiss Patent Office in Bern, the amateur scientist Albert Einstein discovers the 'principle of equivalence', which states that gravity and acceleration are indistinguishable.



Albert Einstein publishes a series of papers on his General Theory of Relativity, which describes gravity as a warp in spacetime that is caused by massive objects.

1915

1919

Arthur Eddington observes a solar eclipse on Principe Island, demonstrating the shift of stars appearing near the Sun. He uses this as confirmation of General Relativity.

objects from particles coming from its direction. This meant that the remaining particles pushed objects towards the Earth.

This sounded very unlikely. But it would take the remarkable mind of Albert Einstein to come up with a better suggestion. His breakthrough thought on gravity came shortly after the remarkable year of 1905, when Einstein wrote three papers that transformed physics. These established the existence of atoms, formed the foundations of quantum theory (for which he won his Nobel Prize) and introduced Special Relativity, which showed how apparently fixed quantities like mass, length and the flow of time varied depending on your viewpoint.

Two years later, Einstein was sitting in the patent office in Bern and had what he described as his happiest thought. Einstein later commented: "All of a sudden a thought occurred to me: if a person falls freely, he will not feel his own weight. I was startled. The simple thought made a deep impression on me. It impelled me towards a theory of gravitation."

Gravity and light

What Einstein had realised was that gravity and acceleration were equivalent and indistinguishable. If, for instance, you were in a spaceship with no windows and found that you were experiencing a pull of 1g, there are two possible explanations. You could be sitting still on the surface of the Earth, or you could be in space and the craft could be accelerating at 9.81 metres per second per second – the same acceleration as due to Earth's gravity. Your instruments could not detect a difference. But if this is true it tells us something odd about gravity.

If we imagine a beam of light crossing the accelerating spaceship, the beam will appear to bend to someone inside the ship as a result of its motion. But since acceleration and gravity are equivalent, the same light beam should also bend in a gravitational field. Einstein had realised that gravity warps space, twisting it near a massive body so that anything travelling in a straight line curves around it. This is as true of an orbiting planet as it is of a beam of light.

In fact, his discovery proved stranger still. While the warping of space explains the orbits of the planets, it doesn't tell us why the apple falls. There is no reason for something to start moving. But it is space-time – the mash-up of space and time that emerged from Special Relativity – that is warped by massive objects, and it is the

NEED TO KNOW

Key terms used when discussing the nature of gravity

1 FUNDAMENTAL FORCES

The four forces of nature: gravity, electromagnetism and the strong and weak nuclear forces. Between them they're responsible for all interactions between particles (and between matter and light).

2 INVERSE SQUARE LAW

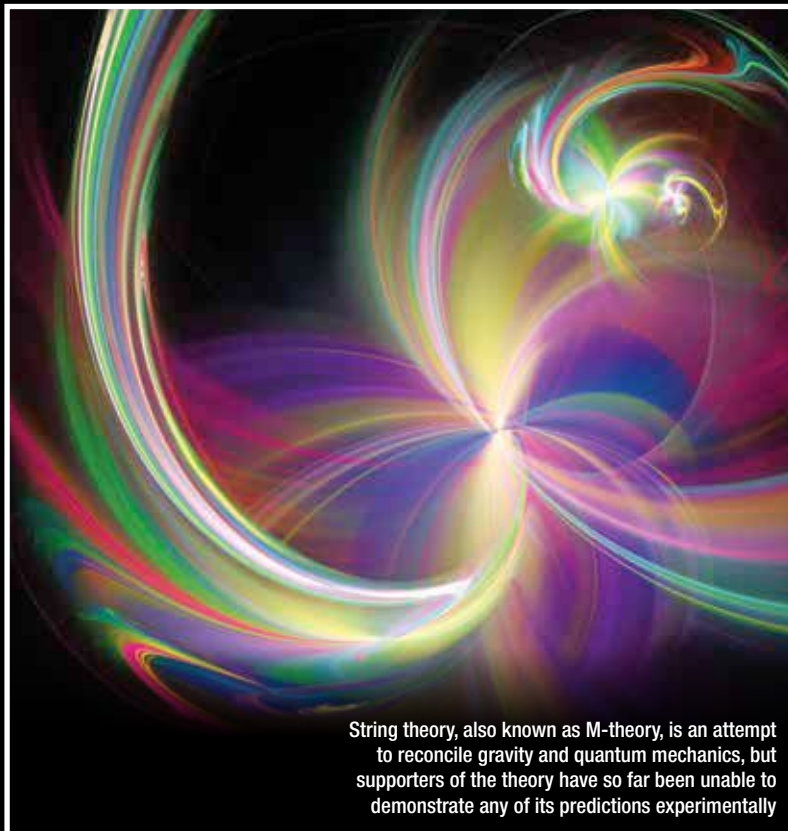
This describes a quantity that gets smaller as the square of a value gets bigger. For instance, if you double the distance between two bodies the gravitational pull is reduced by a factor of four.

3 MASS

A concept introduced by Isaac Newton to describe the amount of matter present. The mass of a body is what causes its gravitational attraction and doesn't vary, whereas its weight is the force of gravity on the mass at a particular location.

4 RELATIVITY

Galileo observed that motion is relative. If we move at the same velocity as something else, it doesn't move with respect to us. Einstein developed this idea in his theories of Special Relativity, reflecting the effect of the fixed speed of light, and General Relativity, which brings in gravity and acceleration.



String theory, also known as M-theory, is an attempt to reconcile gravity and quantum mechanics, but supporters of the theory have so far been unable to demonstrate any of its predictions experimentally

warp that initiates motion. The mathematics to support all this is fiendishly complex – even Einstein had to get help to understand it – but the principle is simple enough.

Einstein had given Newton's theory a framework, a reason for working. More than that, General Relativity, as Einstein's theory became known, made some predictions that were different from those Newton would have expected – and experiments have verified that it is General Relativity that matches reality.

It seemed in many ways that the theory of gravitation was complete. Einstein's development would be used to predict everything from the existence of black holes to the way the Universe changes with time. But there is still one big gap in our understanding. All the other forces of nature are quantized. They aren't continuous, but are granular with tiny divisions called quanta. The expectation is that there should

also be a quantum theory of gravity, but as yet one has not been established. For a while it seemed as if string theory would provide the answer, but there is increasing concern that this mathematically-driven concept will never make useful predictions, leaving growing interest in alternative theories like loop quantum gravity.

Gravity and us

Gravity not only keeps things in place on the Earth, it was responsible for the formation of the Solar System as it coalesced out of a spinning cloud of dust and gas. It's gravity that produces the temperature and pressure in the Sun that, along with quantum effects, make it undergo nuclear fusion to generate the heat and light that gives us life.

Experiments in space have even shown that gravity is essential for living things. Plants struggle to grow with no gravity to direct their roots. In an experiment on the

International Space Station, it has been shown that birds' eggs need gravity to develop. And human beings deteriorate in low gravity, losing bone density and muscle tone, while lungs suffer compression as organs drift upwards with no gravity to keep them in place.

Gravity maintains some secrets. We don't know, for instance, why it is so much weaker than the other forces. If you doubt this, compare it with electromagnetism: in picking up a paperclip, a small fridge magnet overcomes all the gravity the entire Earth can muster. Nor do we know how to bring gravity into the quantum fold. But thanks to the work of Newton and Einstein, this fundamental force is no longer a total mystery. ■

Brian Clegg is a popular science author with books including *Gravity: Why What Goes Up, Must Come Down*.

PUZZLE PIT

Questions and challenges guaranteed to give your brain a workout

SEND IN YOUR
ENTRIES
AND
WIN EXCITING
PRIZES

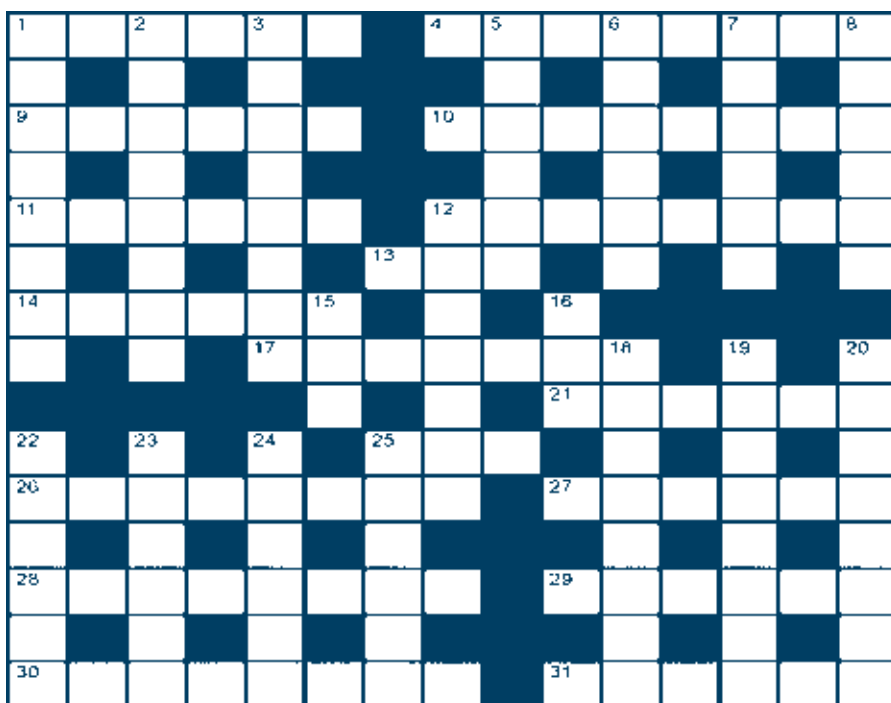
Crossword No.26

ACROSS

- 1 Pertaining to flowers (6)
- 4 Father of India's Constitution (8)
- 9 Chennai's old name (6)
- 10 One who takes something for temporary use or (8)
- 11 Cowboy's rope; lasso (6)
- 12 The science of bodies in motion? (8)
- 13 PC alternative (3)
- 14 The king of the Huns in 4th century B.C. (6)
- 17 Narrow neck of land (7)
- 21 Economy or prudence (6)
- 25 Illuminated (3)
- 26 Beauty is in the eye of the ____? (8)
- 27 Bristlelike structure or appendage - ""is a rat"" anagram?" (6)
- 28 Scolding, admonishing or berating (8)
- 29 Money given back (6)
- 30 Photograph (8)
- 31 Questioning, inquiring or inviting (6)

DOWN

- 1 Chummy (8)
- 2 Stubborn and unyielding (8)
- 3 Indian mountain range (8)
- 5 Short-sighted (6)
- 6 Gained by work (6)
- 7 Middle Eastern country (6)
- 8 The most uncommon (6)
- 12 Srinagar locale (7)
- 15 Powdery residue (3)
- 16 __ out: protrude outward (3)
- 18 Hones, grinds or whets? (8)
- 19 Jefferson City is the capital of this U.S. state (8)
- 20 Lowly mongrel having no owner? (5,3)
- 22 Severs, stops or terminates (6)
- 23 "B" in BARC? (6)
- 24 Particles of falling snow (6)
- 25 A small shed with a sloping roof? (4-2)



YOUR DETAILS

NAME: _____

AGE: _____

ADDRESS: _____

PINCODE: _____

TEL: _____

MOBILE: _____

SCHOOL/INSTITUTION/OCCUPATION: _____

EMAIL: _____

How to enter for the

crossword: Post your entries to BBC Knowledge Editorial, Crossword No.26 Worldwide Media, The Times of India Bldg, 4th floor, Dr Dadabhai Navroji Road, Mumbai 400001 or email bbcknowledge@www.co.in by **10 June 2015**. Entrants must supply their name, address and phone number.

How it's done: The puzzle will be familiar to crossword enthusiasts already, although the British style may be unusual as crossword grids vary in appearance from

country to country. Novices should note that the idea is to fill the white squares with letters to make words determined by the sometimes cryptic clues to the right. The numbers after each clue tell you how many letters are in the answer. All spellings are UK. **Good luck!**

Terms and conditions: Only residents of India are eligible to participate. Employees of Bennett Coleman & Co. Ltd. are not eligible to participate. The winners will be selected in a lucky draw. The decision of the judges will be final.

WINNERS FOR CROSSWORD NO. 25

Parikshith Mohan, Coonoor

Chandini Raghuraman, Mumbai

Sujata Sethi, Haryana

SOLUTION OF CROSSWORD NO. 25



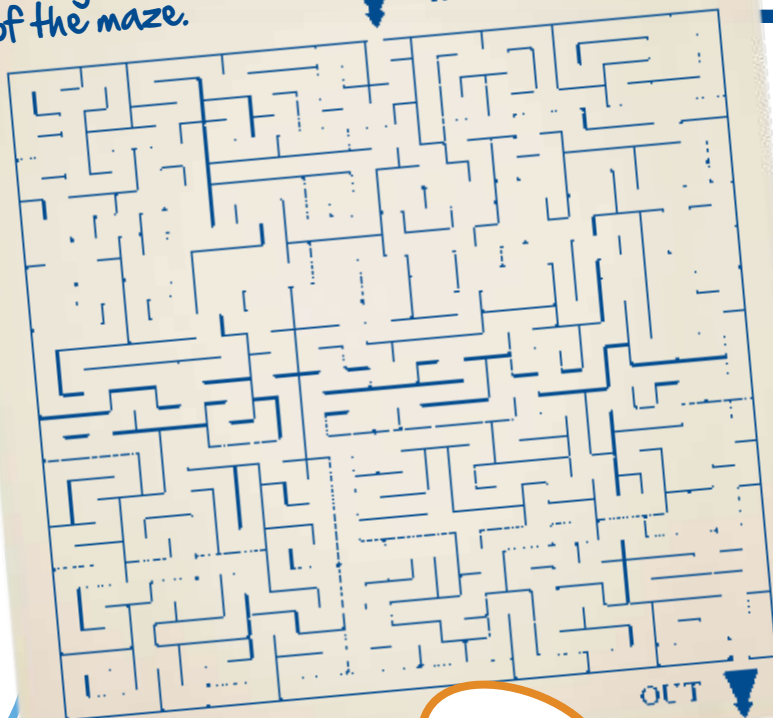


Q2 HEAD AND TAIL

Look at the clue to solve the answer in the form of a compound word. The second part of the next answer is the first part of the next answer.

Hair style	Crew	
Curtail		
Inadvertent connection		
Type of Judicial tribunal		
Official demand		
_____ the day		
Useful		Value

Find your way out of the maze.



Q1 PICTURE SEARCH

In the jumble below, the words represented by each of the 16 pictures are hidden either horizontally, vertically or diagonally forward or backwards but always in a straight line. See how many of them you can find? Look out for descriptive names.



S H N Q J Y M N Z C V
O W E L A P A X Y M G
H B V A S E T X M Z T
W M O U E A A Y W R H
N O I D R O C C A K I
F L Z M B A B O O N G
I U N U V F I S G H L
N C Y L F T H S K D O
G A O P M A O X S A O
E N N R R N R R A U L
R N B K U K H A R P R
A O U A I E U H F A B
V N B V Y C P C W K C

Q3 SCRAMBLE

Solve the four anagrams and move one letter to each square to form four ordinary words. Now arrange the letters marked with an asterisk (*) to form the answer to the riddle or to fill in the missing words as indicated. In the middle of _____ lies opportunity. — Albert Einstein (10).

ILITM		*		*	*
RLBUY		*		*	*
EIKWCD			*		*
AELRFF			*	*	

SOLUTIONS:
Q1 Picture Search: Accordion, baboon, cannon, carrot, Euro, finger, igloo, kite, mat, oven, plum, Russia, shark, thermometer, tie, vase
Q2 Head & Tail: Crew-Cut-Short-Circuit-Court-Order-Of-Value
Q3 Scramble: Solution: Words: Limit, burly, wicked, raffle
Answer: In the middle of difficulty lies opportunity. — Albert Einstein

MINDGAMES

Test your knowledge with our Big Quiz set by James Lloyd

1 Scientists created a computer program that they say is a perfect player of which game?

- a) Blackjack
- b) Poker
- c) Gin rummy

2 Complete the recent headline: 'Regular _____ are key to learning'

- a) Snacks
- b) Naps
- c) Jogs

3 January marked 10 years since an ESA probe landed on Saturn's moon, Titan. What was the probe's name?

- a) Huygens
- b) Herschel
- c) Hawking

4 Which came top of SplashData's list of 2014's most popular passwords?

- a) password
- b) 123456
- c) qwerty

5 To celebrate its 25th birthday, Hubble has revisited the iconic 'Pillars of Creation'. Where are they found?

- a) Crab Nebula
- b) Horsehead Nebula
- c) Eagle Nebula



The red streaks are an iconic feature of...



6 This weird marine creature has been captured in waters off southeast Australia. What is it?

- A) Fanged shark
- b) Finned shark
- c) Frilled shark

7 Complete the recent headline: 'Computers judge _____ better than friends'

- A) Personality
- b) Intelligence
- c) Fitness

8 Astronauts were recently evacuated from a US segment of the International Space Station after a suspected leak of what substance?

- a) Carbon monoxide
- b) Methane
- c) Ammonia

9 Tracking devices have revealed the world's highest bird migration. Which bird makes the journey, reaching heights exceeding 7,000m?

- a) Pied wheatears
- b) Arctic terns
- c) Bar-headed geese

10 Researchers in the US have built a microwave laser ('maser') that's the same size as what?

- a) A grain of rice
- b) A golf ball
- c) A dust mite

11 What kind of animal is Tilda, recently filmed mimicking human speech in a bid to communicate with her keepers?

- a) Dolphin
- b) Orangutan
- c) Raven

12 Researchers at the University of Surrey have found that doing what can help you to recall memories?

- a) Clenching your fists
- b) Holding your breath
- c) Closing your eyes

13 Which British soprano recently began training for a trip to the International Space Station?

- a) Lesley Garrett
- b) Sarah Brightman
- c) Charlotte Church

14 In January, the missing Beagle 2 was finally found on the surface of Mars. When did it initially land on the Red Planet?

- a) December 1998
- b) December 2003
- c) December 2008

15 According to a recent study, what's the most likely function of the zebra's black and white stripes?

- a) To keep them cool in the African heat
- b) To camouflage them from predators
- c) To help them identify each other





16 Climate change is having what unlikely effect on chamois mountain goats in the Italian Alps?

- a) It's making them shrink
- b) It's changing the sound of their mating call
- c) It's giving them finer pelts

17 In October 2014, the Queen sent her first ever tweet. But where did she send it from?

- a) The London Eye
- b) The Tower of London
- c) London's Science Museum

18 This year's Nobel Prize in Physics was won by the inventors of which colour LED?

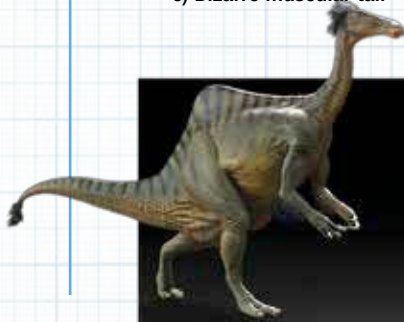
- a) Blue
- b) Green
- c) Red

19 Complete the recent headline: "Sex emerged in ancient _____"

- a) Welsh bog
- b) Scottish lake
- c) Irish spring

20 Recent fossil finds have helped scientists reconstruct this odd 'beer-bellied' dinosaur. What does its name, *Deinonychus mirificus*, mean?

- a) Unusual horrible hand
- b) Strange stripy hump
- c) Bizarre muscular tail



21 According to analysis by an instrument aboard the Rosetta spacecraft, the Churyumov-Gerasimenko smells of all but one of these – but which one?

- a) Rotten eggs
- b) Mouldy cheese
- c) Horse urine

22 Which one of these research topics was not a winner in 2014's Ig Nobel awards?

- a) Measuring the amount of friction when someone steps on a banana skin
- b) Investigating why people often see the face of Jesus in a piece of toast
- c) Estimating how many of the world's centipedes actually have 100 legs

23 A recent study found that musicians in what genre tend to be more extroverted?

- a) Folk
- b) Jazz
- c) Classical

24 Which country has sent the Mars Orbiter Mission into orbit around the Red Planet, becoming the first nation to reach Mars on its first try?

- a) Russia
- b) China
- c) India

25 Google's Alan Eustace has set a new record for the highest ever free-fall jump. From what height did he jump?

- a) 11km (36,000 feet)
- b) 26km (85,000 feet)
- c) 41km (135,000 feet)

26 Analysis of bones from a Roman cemetery has revealed that gladiators mostly ate what foods?

- a) Bread, cheese and baked rabbit
- b) Wheat, barley and beans
- c) Wild boar, figs and olives

27 A recent auction broke the record for the most expensive Apple computer ever sold. How much did the Apple-1 go for?

- a) \$405,000
- b) \$905,000
- c) \$1,405,000

28 Benedict Cumberbatch recently played mathematician Alan Turing in *The Imitation Game*. What was the name of the machine that Turing designed that helped crack the German Enigma code in WWII?

- a) The pomme
- b) The bombe
- c) The rombe



QUIZ ANSWERS:
1a, 2a, 3b, 4a, 5b, 6c, 7c, 8b, 9c,
10b, 11a, 12b, 13c, 14a, 15c, 16a,
17c, 18a, 19b, 20a, 21b, 22c, 23a,
24c, 25c, 26b, 27b, 28b

EDU TALK

Principal **Jayashree Nambiar** of The School KFI (Krishnamurti Foundation India), Chennai emphasises on a holistic form of learning

How does The School, KFI define good education and provide the same to its students?

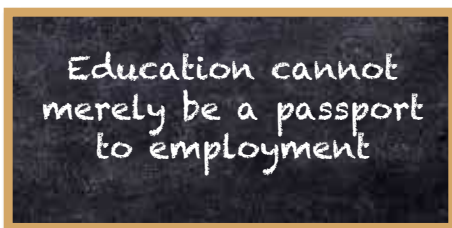
The School brings together a group of teachers who experience, if I may put it this way, an active discontent with education and life as it is. It brings together teachers interested in an exploration of education in the light of the work of educationist and philosopher J Krishnamurti. There is certainty that fear and coercion cannot bring about real and lasting learning. The attempt is to create an atmosphere where a student can find the motivation to learn and act that is not from competition or comparison, which is free of reward and punishment. Education cannot merely be a passport to employment. Academic learning is embedded in this larger learning and in the relationship between the teacher and the student.

How is the curriculum designed by The School integrated into the ICSE prescribed curriculum from Class VIII onwards?

The curriculum designed by the school keeps to the guidelines of the CISCE and works towards the syllabi of the ICSE and ISC. The curriculum focuses on significant aspects of learning - finding connections between subjects, questioning what one comes across, understanding the concept to enable application, ensuring through all that is learnt that the windows to the world are open.

Classes at The School, KFI have students in mixed age groups. How are their diverse learning requirements addressed in a single classroom?

Students learn in different ways and at different paces. This is true of any group of children or adults. When students learn in mixed age groups the differences are acknowledged and appreciated. The demand is that the teacher be aware of varying ways of learning and address these. It is difficult to have a pre-conceived level of learning that the teacher relies on to see who are making the mark and who are not. The student is free to explore further or take his/her



time over learning a particular topic. There needs to be no sense of superiority or inferiority when a child learns individually and has the support of a group. In the legitimising of different styles the teachers finds different ways of engaging students and the students find different ways of learning.

The School, KFI places a great emphasis on extra-curricular activities, including physical activities, social services, practical skills and artistic and cultural endeavours. What is the driving force behind this extensive extra-curricular programme?

The driving force behind much of what is done at school comes from the understanding that education and life are not essentially different. Physical activities promote team building, stimulate the growth and development of sensorial and motor development, team-building skills. Art classes encourage creative, observational and innovative exploration of the environment students are exposed to. Field stays outside of Chennai, offer students the potential to understand social issues and interact with individuals who work to solve them.

What do you think are some of the traditional Indian education system's shortfalls, and how does the approach at The School, KFI address those?

Insufficient agency to the teacher within the education system, the notion of teaching as the effective delivery of information alone, the need to work for examinations that have unrealistic syllabi and test recall alone, orientation towards achievement, narrowing definitions of success - these are perhaps aspects of education that need to be examined honestly by teachers and education policy makers of our country.

A serious shortfall is that the classroom is tyrannised by the text-book and examinations and marks. It is further tyrannised by fixed notions of conformity to a world that despite our rigidities is changing everyday. It is near impossible for us to predict what world our students will be adults in will look like. The School addresses these in its manner of administration, through conversations among staff and with students, creation of curriculum, pedagogical approaches that among other things attempt to give examinations its right place.

- Edited by Moshita Prajapati

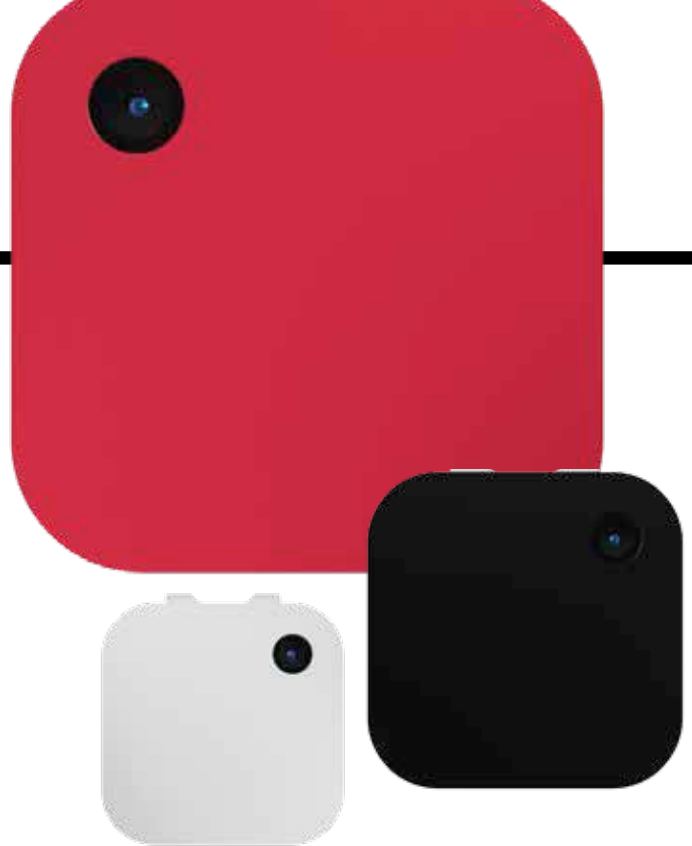
GADGETS

Narrative Clip 2

In this ultra-connected age, wouldn't it be wonderful if we could actually experience life instead of obsessively documenting it through our phone cameras? The Narrative

Clip 2 has an answer to that. This unobtrusive, hands-free camera is an upgraded version of the first Narrative Clip that launched in 2014. Simply put, this camera is always on; capturing moments at a steady clip and storing and sorting them for the user to upload. Equipped with WiFi and Bluetooth, the Narrative Clip 2 captures photos at timed intervals and is compatible with Android and Windows phones.

Price: ₹12,383 • www.getnarrative.com



An Assortment



Davek Alert Umbrella

On a rainy day, you'll be glad to have the Davek Alert Umbrella with you. It has a well-crafted design and is durable enough to rely on in a heavy downpour. But no umbrella, no matter how well made, can protect you from the weather if you've left it at home. This umbrella comes embedded with a Bluetooth chip in the body that alerts you through your smartphone if you're leaving it behind. This link between you and your umbrella will ensure you're never stuck taking shelter at a bus stop again.

Price: ₹6,160 • www.davekny.com



Blocks Modular Smartwatch

The company Blocks seems to have wholeheartedly embraced the rising popularity of modular technology. The Blocks Modular Smartwatch brings the modular concept in to the smartwatch arena. This device provides a customisable alternative to the other smartwatches that allow no room for personalisation. The

wristband's links serve as independent modules, allowing users to add a GPS tracker, a fitness tracker, an SD card slot and even an extra battery to the smartwatch. The watch face holds the entire device together with a touch display and processor.

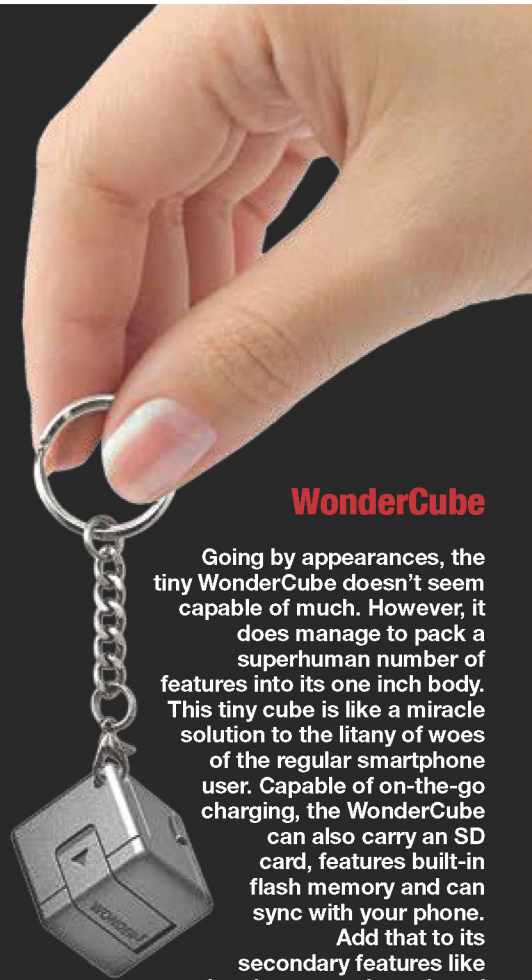
Price: TBA
• www.chooseblocks.com



Ride Helios

The Helios handlebars are a simple addition that transforms a simple bicycle into a futuristic vehicle. The handlebars are equipped with an array of practical functions to greatly enhance the riding experience. GPS navigation, location tracking, headlights, rear LEDs, turn signals and smartphone compatibility make these handlebars a total package. These handlebars point to an interesting trend where smart components can be smoothly integrated into existing products, elevating the user's experience.

Price: ₹17,360 • www.ridehelios.com



WonderCube

Going by appearances, the tiny WonderCube doesn't seem capable of much. However, it does manage to pack a superhuman number of features into its one inch body. This tiny cube is like a miracle solution to the litany of woes of the regular smartphone user. Capable of on-the-go charging, the WonderCube can also carry an SD card, features built-in flash memory and can sync with your phone. Add that to its secondary features like the phone stand, torch and keyring and this is one gadget you'll want with you every time you leave the house.

Price: ₹4,293
• www.thewondercube.com

Beosound Moment

The Beosound Moment music system from Bang & Olufsen promises two times the fun, with a dual interface composed of a wooden and aluminium interface on either side. The Beosound Moment also boasts the world's first-ever wooden touch surface. The classic look of the wooden interface is offset by the futuristic aluminium one. In addition to its striking design, this music system curates soundtracks from a selection of 35 million songs on the global streaming service, Deezer.

Price: ₹1,73,919
• www.bang-olufsen.com

Waytools Textblade

In spite of touch screen technology's ubiquitous presence in most gadgets today, finding someone who enjoys typing on those over-sensitive screens is a practical impossibility. The Waytools Textblade brings the convenience of typing on mechanical keyboards to the touch screen era. The Textblade collapses into a thin strip only 1/3rd the size of an iPhone, and opens out into a QWERTY keyboard. It connects via Bluetooth to tablets and smartphones, and its three rows of keys reduce the sprawl of the traditional keyboard.

Price: ₹6,160 • www.waytools.com



- By Dushyant Shekhawat

GAMES REVIEW

BLOODBORNE

PS4, Xbox One: ₹4,299; PS4, Xbox 360: ₹3,999; PC: ₹3,799

The gothic town of Yharnam and its surroundings provide the backdrop for the action in *Bloodborne*, where the player controls an individual known simply as The Hunter. The Hunter stalks through Yharnam, and is stalked in turn by the multitudes of ravening monsters that afflict the town. The desolate beauty of the game underlines the tension you feel while exploring it.

Gameplay in *Bloodborne* is punishing, where death goes hand in hand with losing all in-game currency. The combat system encourages fast-paced duelling with enemies, allowing you to recover health only if you successfully land a counter attack. The weapons in the game transform into super-weapons, which open up newer and more powerful attacks, in spite of being less wieldy.

All this, combined with the open world setting, contributes to a steep learning curve that could cause novice players some frustration.

For those looking to catch a breather from the gruelling gameplay, the game's story hides in the shadows, awaiting discovery. Exploring the nooks and crannies of Yharnam can often yield a nugget of information that furthers your understanding of what exactly is taking place in the town. The non-linear presentation of the story keeps players involved as they try to piece together the plot while fighting off droves of demons and monsters.

It takes patience to beat *Bloodborne*. The game challenges its players from the first level onwards and doesn't relent at any point. For gamers looking for an opportunity to test themselves, *Bloodborne* is the best title this year.

Try not to succumb to the Gothic horror that defines *Bloodborne*'s world

FINGER ON THE BUTTON

Google gets playful

Google welcomed April 2015 by hiding two neat little Easter eggs in its services. For fans of the 80s classic Pacman, Google Maps now runs a version of the game where your city streets form Pacman's maze. Also, the Lonely T-Rex mascot, synonymous with crashed web pages on Google Chrome also gets an endless running game. How do you find and enjoy these Easter eggs? Just Google it!



Special edition Mortal Kombat coming to stores

The brand new instalment of the *Mortal Kombat* franchise is going to hit shelves with a special edition, called the Collector's Edition. Along with a copy of the game, buyers will receive a bundle of fan memorabilia, including a hand-painted statuette and a special comic book.



The International 2015 dates announced

The biggest prize in e-sports is up for grabs once again, as Valve announces that the global DOTA 2 tournament, The International, will be held from 3-8 August. Last year's prize pool climbed upwards of 10 million USD, so this event will surely be one to watch.



- Compiled by Dushyant Shekhawat

INSIDE THE PAGES

ON THE SHELF Books adapted into films

THE BOOK THIEF

by Mark Zusak

The year is 1938 and Liesel Meminger is living with her foster parents Hans and Rosa Hubermann in Nazi Germany. Taught to read by her adopted father, she takes adeptly takes to reading. 'Borrowing' books and sharing it with Max, a Jewish man living in her basement, she experiences both the humanity and adversity of life whilst living under the long shadow of Hitler's regime. Adapted into a movie, the 2013 film stays true to the novel's narrative style and brings to screen a new perspective of teenage life in Nazi Germany.

LEMONY SNICKET'S A SERIES OF UNFORTUNATE EVENTS

by Daniel Handler

The series follows the lives of the three-orphaned Baudelaire children who following the death of their parents in a mysterious fire and are placed in the custody of their guardian, the notorious Count Olaf. Olaf's futile attempts to rob the children of their inheritance leads them towards a series of unfortunate events, where the children manage to outwit him by their wits only to have another tragedy befall them. Self-deprecating in its narrative, the 2004 movie adaptation of the novel, where Jim Carrey played the cunning and deceitful Count Olaf was widely appreciated.

JURASSIC PARK

by Michael Crichton

Don't get us wrong; the book did come out first. Steven Spielberg's blockbuster Jurassic Park pretty much kept to the main story line of the book. Paleontologists Alan Grant and Ellie Sattler along with mathematician Ian Malcolm arrive on an invitation by John Hammond to tour the park populated by dinosaurs genetically re-created from a pre-historic DNA. Havoc breaks out when the power failure to the park is cut and the dinosaurs break out and start hunting out the visitors one by one. While in the book, the island is set to fire and destroyed, and the dinosaurs extinct once again, in the movie, they were kept alive for a sequel.

MATILDA

by Roald Dahl

The 1996 film adaptation of the classic novel by Roald Dahl follows the life of five-year-old Matilda a gifted child who is forced to live with her neglectful parents. School is no better; her headmistress Mrs Trunchbull is a mean bully. Life brightens up for Matilda when she realizes she has the power of telekinesis. Elated, she starts to defend her friends and teacher Miss Honey from the evil headmistress and chart her escape from her cold and distant parents.

HOW TO TRAIN YOUR DRAGON

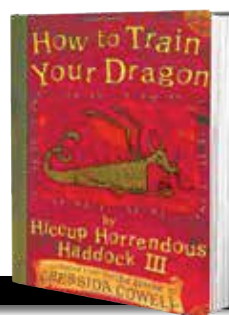
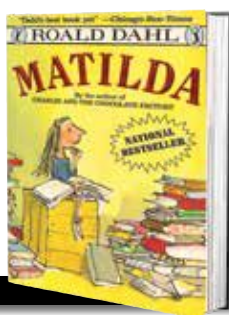
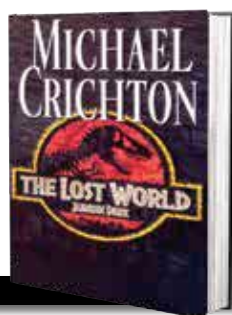
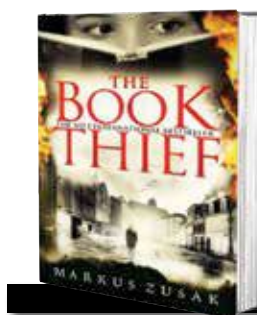
by Cressida Cowell

Adapted into a movie in 2010, the film follows the mis-adventures of Hiccup the teenage Viking who has never really fit into the Viking way of life, which is to train and fight dragons. Having chanced upon an injured dragon whilst walking, he uses his un-Viking methods to not only heal and train the dragon, he also ends up befriending him, to the dismay and anguish of his fellow peers. Much to his shock, he realises that he and Toothless, his dragon, now have the power to change the future of his village thanks to their unlikely friendship.

THE JUNGLE BOOK

by Rudyard Kipling

Who doesn't know of the tale of Mowgli, Baloo, Bagheera, Kaa and Shere Khan? Kipling's Jungle Book has captured the imagination of readers ever since it first came out. Wolves in the jungles of India bring up Mowgli abandoned as a baby. Kaa the python, Bagheera the panther and Baloo the bear teach him about rules of living in the jungle and life in general. The story has been adapted in several forms – films, plays, cartoons etc. The most popular one though is 1967 Disney animated film.



BBC KNOWLEDGE PICKS THE TOP 5 FANTASY SERIES



HIS DARK MATERIALS TRILOGY

- PHILIP PULLMAN

Inspired and influenced by the message in Milton's *Paradise Lost*, Pullman's *His Dark Materials* merges physics, theology and philosophy with love, friendship, loyalty, family, honour. This fantasy trilogy by Pullman – *Northern Lights*, *The Subtle Knife* and *The Amber Spyglass* engages us in a world like ours but not quite like ours. Filled with fantastic beasts, witches, daemons, and armoured polar bears, the series is coming of age story of Lyra Belacqua and Will Parry as they find themselves embroiled in a cosmic war involving angels and humans.



ARTEMIS FOWL

- EOIN COLFER

A criminal mastermind who is all of 12-years-old is accompanied by his Butler to restore the family fortunes. Where is the fantasy part you ask? He plans on kidnapping a fairy and demand fairy gold in exchange for its release. His ploy does work – Captain Holly is kidnapped and he successfully manages to exploit fairy gold and partially manages to restore his family fortune. As the series progresses, he forms an unlikely and uneasy trust and bond with Captain Holly; he requires their aid to rescue his father from the Russian mafia, to Artemis helping the fairies to fight against enemy. In the last book in the series they unite to fight against the common evil Opal Koboi who threatens the release of spirits of the fairy soldiers long thought to be have been buried.



THE CHRONICLES OF NARNIA

- C S LEWIS

A series of seven books for the past fifty years or so have individually or collectively captured the attention of its readers thanks to the fantastical conception of an alternate magical realm by author C S Lewis called Narnia. The series follows the adventures of several children who on Aslan's call enter and travel through Narnia, engage in a battle against evil with the help of creatures in a bid to protect the throne of Narnia for its rightful heir.



WHEEL OF TIME

- ROBERT JORDAN

The *Wheel of Time* is considered one of the greatest fantasy series of the modern era. Spanning 14 volumes, the series was originally written by James Oliver Rigney, Jr., under the pen name Robert Jordan.

Following Jordan's death, Brandon Sanderson took over the reins to write the final three volumes. Following the exploits of a chosen one against the forces of darkness, *Wheel of Time* is loved worldwide by fans for its large cast of characters, intricate details and expansive lore.

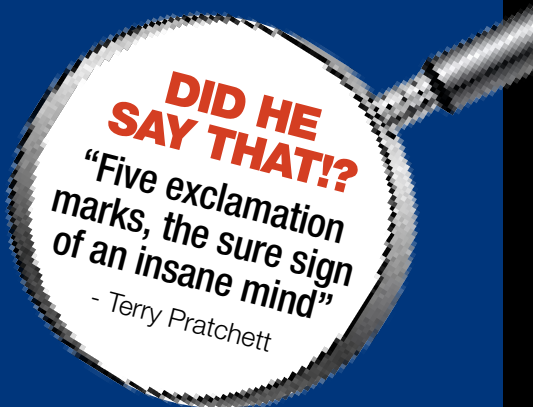


THE SPIDERWICK CHRONICLES

- TONI DITERLIZZI &
HOLLY BLACK

The series chronicles the lives of the Grace children, twins Simon and Jared and their older sister Mallory, after they move into the Spiderwick Estate.

Discovering a boarded-up library in the house, the children stumble upon Arthur Spiderwick's *Field Guide to the Fantastical World Around You*, which shows them hitherto world of magical creatures that exist in their garden. Spread across five books, the plots have enough twists and turns; the siblings are related to Arthur Spiderwick, and the presence of magical creatures such as faeries, ogres, goblins, brownies etc are sure to have the readers look around bushes and trees more carefully to catch a glimpse of these fantastical creatures.



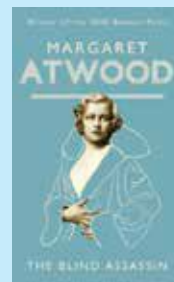
QUESTION OF THE MONTH

'Which author would you like to meet?'

Brandon Sanderson is an author of epic fantasy genre who has written novels such as *Mistborn Trilogies*, *The Stormlight Archive*, *The Reckoners*, *Elantris* and many more. His stories involve beautiful worlds, amazing magic systems and awesome characters. A brave writer, he isn't afraid to kill off the main character in a series or book. In my opinion he is the best thing that has happened in the 21st century and other fantasy authors out there need to know that he is a force to be reckoned with. He is my favorite fantasy writer and people who love fantasy genre should definitely check out his books as they are totally worth our time and money.

- Pallabi Dutta, Telangana

READER REVIEW



The Blind Assassin

by Margaret Atwood

My first Atwood, this book is melancholic, in an almost brutal way. Put simply, it's the story of two sisters, with a somewhat dystopian twist to

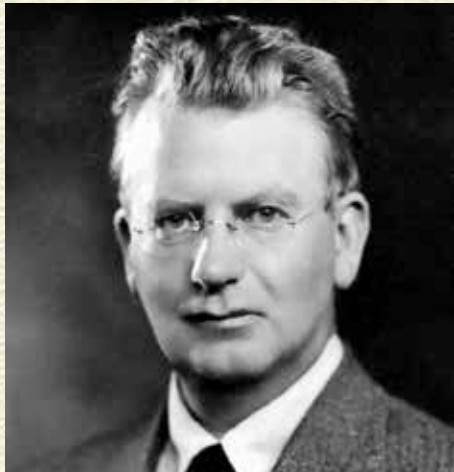
it. However, therein ends its simplicity.

With sheer brilliance, Atwood blends together five different narratives, combines them with shifting timelines, complicated storylines, newspaper clippings, and weaves together an intricate yarn, a perfect piece of literature. The story-within-a-story has been impeccably executed.

What left me breathless was the finesse with which the intertwined stories all come together at the end and literally knock you off. This book is so different, it's a must read.

- By Sonam Chamaria, Telangana

IN FOCUS



John Logie Baird

“Go down to the reception and get rid of a lunatic who’s down there. He says he’s got a machine for seeing by wireless!”

- The shocked response of the news editor of the Daily Express newspaper on hearing that John Logie Baird had invented the television

LEGACY

John Logie Baird (14 August 1886 – 14 June 1946) was a Scottish inventor credited with developing the first working mechanical television. He also contributed significantly to technological advancements in broadcasting and transmission of moving images and the development of the electric television.

With limited resources and a dearth of professional experience, Baird fashioned the world’s first mechanical television apparatus using an old hatbox, darning needles, bicycle light lenses and a used tea chest in 1923. From there he continued to make advances with television technology, leading to the first public demonstration of a working television on 19 March, 1925 in London.

Over the next few years Baird’s fascination with television led him to further breakthroughs, including the first long-distance television transmission from London to Glasgow in 1927 and the first transatlantic transmission from London to Hartsdale, New York in 1928. By 1944, electric televisions had replaced mechanical systems, and Baird remained at the forefront of the field, being responsible for the first demonstrations of colour televisions fitted with cathode ray tubes, a direct precursor to today’s television sets. He passed away on 14 June, 1946 due to a stroke.



Baird used ventriloquists dummies in his early experiments as the harsh lights illuminating his subjects were too bright for human eyes

DID YOU KNOW



At first, Baird’s television could only reproduce images in very low resolution

- The first television picture Baird transmitted was the head of a ventriloquist’s dummy he named Stooky Bill.
- Baird’s mechanical scanning technology survives today and is used in infrared cameras for military purposes.
- The Australian television industry’s premier awards event is called The Logies in Baird’s honour.
- Baird’s failures might be even more impressive than his success; he once shorted out Glasgow’s entire electricity supply trying to create diamonds by heating graphite.



Knowledge



Knowledge

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